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MEMBER OF GOVERNMENT RESCUE CORPS EQUIPPED WITH OXYGEN HELMET READY TO ENTER MINE WHERE DISASTER HAS TAKEN PLACE.

THE PREVENTION OF MINING DISASTERS.—[See page 120.]

COAL: ITS COMPOSITION AND COMBUSTION.*

GENERAL DISCUSSION OF THE ELEMENTS THAT PROMOTE COMBUSTION.

BY WILLIAM H. BOOTH.

IT IS usual to speak of heat under various names. It is thermometric, specific, or latent. By the first is meant that property of heat which sets up molecular vibrations in a substance, which are capable of transmission to surrounding bodies by radiation or by contact.

By specific heat we mean the amount of heat energy that is necessary to set up a certain degree of thermometric heat in a unit or mass of some body. The same addition of heat to a pound of lead that has made a pound of water comfortably warm would enable the lead to burn a hole through a man's hand.

By latent heat is understood heat that has become converted into energy of condition without thermometric manifestation, as when heat added to ice at 32 deg. F. enables that ice to exist as a free liquid and still only to affect the thermometer to 32 deg. F. Here, heat represents mobility of the molecules.

In a wide general sense every chemical reaction may be cited as a combustion. Certainly the converse is true—combustion is a chemical reaction. All substances are, in a broad sense, fuels. Many are difficult to ignite. Many have already entered into combustion or are results of chemical processes so energetic that it is difficult to establish any other reaction. Lime, for example, is the product of a combination of the metal calcium with the gas oxygen, and the energy of union is so great that the metal calcium, though one of the most common of nature's so-called elements, is hardly known except as an oxide or a carbonate.

Aluminium is a metal that unites so firmly with oxygen that it will usurp the place of iron in a mass of burned iron, and convert a mass of mill scale into pure iron by itself becoming an oxide. Hence the thermit process. The fuels that are commonly regarded as fuels are wood and coal and mineral oils. These are found free in nature, and are easily burned and give out considerable heat. Ages of experience have taught us that air is necessary to combustion. The fire of wood burns the better when the wind blows upon it. The wind we can feel, if we cannot see it. The effect is to blow away the CO_2 and leave the fuel freely exposed to fresh supplies of oxygen.

Carbon gas is ideal only. Carbon exists, as gas, in the electric arc at 3,600 deg. Cent. When carbon is burned to monoxide, CO, there are set free 4,415 B.t.u. per pound. When this monoxide is burned to dioxide a further heat of 10,232 B.t.u. is set free. Why the difference? Physicists say that the first oxidation also generates at least 10,232 B.t.u. or 5,817 units more than is thermometrically discoverable. They say that the 5,817 units have become latent because the carbon which was solid is now gaseous in the CO. Therefore, the total heat of combustion of carbon gas, if carbon could be taken in its gaseous form, is $10,232 \times 2 = 20,464$ B.t.u. per pound.

Now, in CO_2 there are 12 deg. of C and 32 deg. of O, or

$$C : O : : 3 : 8.$$

Then $20,464 \times \frac{8}{3} = 7,674$

B.t.u. produced by the combustion of 1 pound of oxygen.

Now, for combustion with hydrogen: One pound of this gas gives 62,100 B.t.u. The ratio of the two elements H_2O is 1 : 8.

Now, $62,100 \times \frac{1}{8} = 7,763$

B.t.u. This is almost exactly the heat developed when oxygen is destroyed by gaseous carbon.

In each case three volumes of gas become two volumes, so there is no difference due to a different degree of condensation. Let there be next taken the heat of combustion of a series of hydrocarbons: C_2H_2, C_2H_4, CH_4, C_2H_6 and C_6H_6. These are shown in the second column in B.t.u. per pound of the hydrocarbon.

	B.t.u.	B.t.u.
C_2H_2	$= 21,850 \times 26/80$	$= 7,003$
C_2H_4	$= 21,927 \times 28/96$	$= 6,395$
CH_4	$= 24,017 \times 16/64$	$= 6,003$
C_2H_6	$= 22,338 \times 30/112$	$= 5,982$
C_6H_6	$= 18,094 \times 78/240$	$= 5,880$

for benzine vapor.

$C_6H_6 = 17,930 \times 78/240 = 5,827$

for benzine liquid.

In the third column is the ratio of the oxygen consumed, and in the fourth the heat units per pound of oxygen used. This table gives room for thought. It shows, in the first place, a gradually decreasing result in heat set free per pound of oxygen destroyed. Between C_2H_2 and C_6H_6 two hydrocarbons, with exactly the same proportions of carbon and hydrogen, using up exactly the same weight of oxygen per pound of each, there is a difference of heat set free of 17 per cent (nearly). Burned as vapor and burned as liquid, benzine or C_6H_6 gives a different amount of heat again. The figures become confusing when thus treated, and it is necessary to deal with them by the molecule, as they are treated by the chemist.

How coal is formed cannot be said with absolute certainty, but the probability is that the coal plants accumulated like the accumulation of the peat bogs and became buried in sand and gradually sank to a considerable depth in the earth. There under the influence of heat and pressure, the vegetable matter changed its nature. Its watery constituents were driven off and the remaining portions carbonized, and then were also set up those reactions that produced what we term the bituminous quality. There is no bitumen in coal, but what we mean by bituminous is known to all. Some coal was so much heated that its hydrocarbonaceous matter was driven off to be absorbed in other rocks, such as certain clay shales, or it escaped to the surface and was lost. Thus possibly the Welsh coal was formed with its short flaming qualities that earn for it the term "smokeless," because, though not smokeless in all circumstances, it can be burned without smoke if any simple precautions are taken. Exposed to still greater heat or pressure or both almost all the hydrogenous matter is driven off and the coal is converted into anthracite, a flinty hard variety of carbon.

If samples of coal be examined their composition cannot be regarded as so different as is their behavior. There is a substance found in parts of the West Indies which resembles anthracite in appearance, but it is plastic brittle. It is said not to contain more than 1 per cent of hydrogen to 99 of carbon. Yet this 1 per cent entirely changes the nature of the carbon, producing a smoky fuel and the capacity of becoming soft with but a moderate heat. Ordinary bituminous coal contains very much more hydrogen but does not soften at the same low temperature, and when it is exposed to heat it softens in spots and gives off tar vapors. Nothing is known really of the chemical composition of coal. It can be found out easily and with close accuracy just how much hydrogen, how much carbon, oxygen or sulphur a piece of coal does contain; but how the atoms of these elements are joined together seems quite beyond finding out. Thus, if a piece of coal be exposed to distillation in a retort and the different things collected that are produced, there will be found tar, creosote, carbolic acid, cresylic acid, hydrogen, various light and heavy hydrocarbon gases, and so much water and ammonia. But it cannot be said these substances are present in the coal. They have simply been built up or broken down from the material of which coal is really formed, and for anything known to the contrary, a piece of bituminous coal is homogeneous throughout in chemical composition and only splits up into many and various bodies when heated. But since it cannot be known what this substance is there is no reason further to inquire into it. And it may be inferred that if the coal begins to split up as soon as heated so it will continue to split up as more heat is applied, the material splitting up more and more into lighter and heavier portions so that nothing but pitch remains in the still, and after a little further heating, even this is resolved into coke and vapor.

When coal is burned in a fire exposed to air, there is a perhaps more complicated set of reactions put into operation. These are operations both of distillation and combustion. An experiment first shown by Horace Allen was the sprinkling upon a red-hot plate of porcelain of some finely divided bituminous coal. At once vapor commences to be given off and a dark spot surrounds each bit of coal. The coal does not glow so long as the vapor is coming away from it. When the vapor ceases to escape the coal begins to get hot and the dark spots on the plate disappear. The coal now begins to glow, to sparkle; in fact, to oxidize and disappear.

Now, from this experiment much may be learned. First, that the primary effect of heating coal is to drive off its volatile portions. Actually, of course, heat renders the coal partly volatile and drives this part away. The vaporizing of this demands heat and the vapor renders so much heat latent that it dulls the surface of the plate. When this chilling effect is finished by the escape of all vapor, the remaining bit of coke gradually becomes hotter. But it does not oxidize brightly until it has attained a high temperature. These actions teach that coal upon a grate will be very seriously cooled if fresh coal is thrown upon it, and that the volatile matter must be thrown off any piece of coal before its carbon skeleton will begin to burn. In a thick bed of coked coal on a grate the chilling effect of fresh coal may not extend right down to the grate surface and the fuel next the grate will burn with the incoming air at the same time as the gas from the green coal burns on the surface. If the fuel bed is thin, the carbon dioxide first produced on the grate comes to the surface as dioxide, and hinders the combustion of the volatile matter. If the fuel be thick the dioxide may be converted into monoxide in its upward passage through the fuel, and this will again hinder the combustion of the volatiles. The final gaseous mixture above the fuel will be very complex, and usually it will be by no means very hot. Experience tells, as explained by Mr. Swinburne, that this mixed mass ought to be kept hot in a non-absorbent furnace until combustion is complete.

What now deserves attention is a simple means of examination of a fire with the object of ascertaining to what degree combustion has attained. This is blue glass of a deep tint. Blue glass will not permit the passage of light of a wave length greater than blue. It is because it will not permit this that it is blue. High-temperature radiation has the shortest wave length. Violet light has double the number of waves per inch that represent red light, and red light has millions of times the waves per inch of sound notes. Sound would become visible to a man moving fast enough toward its vibratory origin. Low-temperature flame is red, orange, yellow; blue is hot; violet is so potent that it brings about various chemical reactions, as in photography. A red-hot brick seen through blue glass becomes drab, and gives no illumination. A brilliantly incandescent brick-lined furnace seen through blue glass appears of a light French gray, and is of illuminating quality.

Now, if a dull flaming fire be observed, such as is obtained if badly mixed gases rise directly upward from the fire to pass among cold tubes, there will be seen through blue glass no illumination above the fire beyond about 6 inches. The flames are resolved into dark streams of gas; no light comes from them. But if the interior of a furnace be observed when properly lined with brick, and with suitable direction of flow and air mixture, the whole will be illuminated. Streaks and splashes of dark gas will be seen coming forward over the fire, and these melt away as they travel, and burn and help to keep up the temperature. The dark streaks are simply gas not hot enough to give violet light. They are red or yellow flames of burning gas ready to produce smoke if sent upon cold surfaces. Kept off cold boiler plates, they complete their high temperature combinations, and may then be used for heating anything.

It is not that blue glass marks the state of combustion beyond which one must pass, but it seems certain that if a properly mixed gas attains this temperature before exposure to cold surfaces, it will be properly burned. It would be interesting to experiment with red, yellow, and green glass, so as to find how these help in analyzing the state of a fire. It is certain that if blue glass cuts the flame very short there is imperfect combustion.

Now I have not told you much about coal, for I know nothing myself of the way it is put together. All I can infer is that a very small amount of combined hydrogen will change the physical nature of much carbon. Analysis of coal seems to point to the presence of oxygen as the patent cause of so-called bituminosity. Knowledge of the phenomena of heat—such as latency—teaches that the fuel bed must be chilled when fresh coal is giving off vapor.

On the supposed atomic arrangement of hydrocarbon, speculation may be indulged in on the facts that hydrocarbon is first attacked by the oxygen, and that the carbon is set free by itself or in some different combination with hydrogen, and so readily condenses on the first cold surface. And so it is learned to mix atoms of oxygen in excess of what the hydrogen atoms will snatch up and to maintain everything hot until the carbon has had its chance to find its own atoms of oxygen. And as it may be inferred that a thick fuel bed implies shortness of oxygen above the fire—for the fire has perhaps been converted into a gas producer—so it may be learned not always to regulate combustion at the chimney damper, but to keep this open sufficiently to pull in all the air we need as a maximum above the fire, and to regulate the combustion by combined movements of the door grids and ashpit dampers.

Safety valves are locked up from tampering: why not also lock the chimney damper? It should be

* Abstract of paper read before the Association of Engineers-in-Charge (England).

locked, for it is not fit to be used as a regulator of the combustion of bituminous coal, for this is a double process, the coal burning partially as solid fuel on the grate and partly as gas above the fire, and each operation requires separate and yet conjoint air regulation.

Ordinary coal has a calorific capacity of about 14,000 B.t.u. per pound. The volatile matters distilled from it have a capacity of 18,000 to 24,000 B.t.u. The extra 4,000 to 10,000 heat units they now possess are borrowed from the heat of combustion of the solid fuel on the grate, and when the green gas is wasted unburned it is carrying with it the latent heat of distillation. Assuming 20,000 as its average heat value and assuming one-third of the coal to be volatile, the green gases carry off nearly half the heat value of the coal.

Though the molecular structure of coal may not be discoverable, there can be no doubt as to the results of the systems of combination ordinarily adopted. If fired on the coking system, the gas is driven off more or less steadily and continuously, and places less of a tax on the surface at any one moment in respect of maximum air supply above the fuel to burn the gas than is levied when fresh coal is spread heavily over a fire at more or less wide intervals of time.

The heat of combustion of carbon and hydrogen together is sometimes more and sometimes less than the heat necessary to liquefy or gasify the carbon and to liquefy the hydrogen.

In solid fuel the carbon has not changed its state, but any hydrogen has been somehow rendered solid by its combination with carbon.

The gaseous hydrocarbons become liquid when their molecular weight gets up to about 70 to 80, and solids begin to appear when the molecular weight reaches 128 or 136.

The trouble with coal is that it is not simply a hydrocarbon of even unknown proportion, or a mixture of hydrocarbons. It contains oxygen built into its solid structure, and this oxygen is not necessarily there as water with some of the hydrogen as H_2O. But it is there, and it comes off in distillation, and forms that complex substance—tar. Tar contains phenol, which is C_7H_6O, the carbolic acid basis; and there are phenols with eight and nine carbon atoms, and even ten.

It would fill this whole paper only to name the known carbon organic compounds containing the three elements C, H, and O variously hooked together. But with all the knowledge of the many substances given out from tar, it cannot be said they are present in coal in the form they take on. But the main facts of physics can be relied on. Heat is swallowed up when solids are liquefied or liquids gasified, and these are the things that happen to coal when burned. They retard its perfect combustion, and the engineer who can best fit practice to meet nature's laws on proper conditions will best utilize coal as regards economy and cleanliness. The knowledge of what happens thermochemically in the life history of the hydrocarbons furnishes ample explanation of the failure of ordinary methods of burning it without heat or temperature conservation. The behavior and properties of the gaseous hydrocarbons may be regarded as the gaps in the bounding walls of knowledge through which glimpses may be had sufficient to serve as the jumping-off points of the flying machines of speculative imagination; and after all it is imagination which differentiates the engineer from the mere mechanic. Armies are never likely to be conveyed by either balloon or flying machine, but both these frail craft may serve to point the way by which an army may best proceed. The mere speculative engineer will not perhaps carry out work so well as the constructional man who follows beaten paths, but his speculative habit of mind does enable him to point the way for others to follow.

IRON, GOLD, SILVER, AND TIN AMALGAMS.

FORMULAS FOR MAKING AND USING THEM.

BY FRIEDRICH HARTMANN.

IRON AMALGAM.

IRON is one of the metals which do not combine easily with mercury, and iron amalgam, as such, is not used for plating purposes. Iron which is to be gilded or silvered in the fire must be given a coating of mercury, which is done by making the object perfectly bright by means of pickling or scouring, then rinsing in pure water and boiling in a compound consisting of 12 parts by weight of mercury, 1 of zinc shavings, 2 of green vitriol, 1½ of hydrochloric acid and 12 of water. The green vitriol is first dissolved in the water, the mercury added next, and finally the zinc. A porcelain vessel must be used for the boiling. The object immersed in the liquid is very quickly covered with an even, silvery coating of mercury, after which it is rinsed several times with water, dried in the air, and immediately subjected to treatment with the gold or silver amalgam. From the moment when it comes from the pickling fluid it must not be touched with the hands, for neither the mercury nor the gold amalgam would adhere to any places where it had been taken hold of.

If the object cannot be fire-gilded at once, it is best to keep it under a glass bell-jar or in a box, so that it may not gather dust, and also that the mercury, which is deposited in a very thin layer upon the surface, may not gradually evaporate. If the gold amalgam is applied as soon as the object is taken from the mercury bath and rinsed, it will adhere easily and firmly.

GOLD AMALGAM.

Gold amalgam to be employed in fire-gilding should be prepared from pure gold; chemically pure gold may be obtained by putting commercial gold (broken jewelry, coins or sheet gold) into a porcelain vessel, and pouring over it a mixture of 3 parts of hydrochloric acid and 1 of fuming nitric acid. This should be prepared directly before using. After a short time bubbles will be seen to rise from the bits of metal, and an unpleasant odor of chlorine will be developed. This odor will entirely disappear after a time, and then more of the acid compound (called "aqua regia," because it will dissolve gold, the "king of metals") is to be added. The process can be hastened by gentle warming, but this is usually not at all necessary when sheet gold is used. When all the gold is dissolved, the fluid is to be diluted with five or six times its volume of water, and a solution of green vitriol poured into it. It will be colored temporarily dark brown, and a heavy brown powder will be precipitated, which consists of very finely divided chemically pure gold.

When there is no further precipitation from a sample of fluid, tested by the addition of a solution of green vitriol, this is an indication that all the gold is separated. The fluid is then filtered through paper, and the precipitate which remains upon the paper is washed several times with water and dried. It is a heavy brown powder, in itself lusterless, but will become lustrous when pressed with the polishing-steel. It is, as observed before, chemically pure gold, very finely divided. It dissolves very easily in mercury, the best method of solution being to heat mercury to about 150 degrees C. in an iron crucible, throw the powdered gold upon it and mix the metals with an iron spatula, since the gold, in spite of being denser than the mercury, will float, on account of its being so finely divided.

Twenty-three-carat gold is very generally used in preparing amalgams, and treated in the following way: The gold is cut with scissors into very small fragments, and put into a crucible which has previously been vigorously rubbed with chalk, to prevent the amalgam from adhering. This crucible is heated red hot in a furnace, and eight or nine times as much mercury, by weight, as gold is heated simultaneously in an iron spoon to about 300 degrees C. When the gold is glowing hot the mercury is poured in, and the metals are mixed as thoroughly as possible by rapid and long-continued stirring. After some minutes the crucible is lifted from the fire and its contents poured into a vessel of water to cool. If the amalgam were allowed to cool slowly in the crucible little crystals of gold would be separated, which would be troublesome in the later application of the amalgam to the object gilded. When it has hardened in the water it is wrapped in a piece of heavy leather tanned with oil, and subjected to powerful pressure, whereby the mercury which has not combined with the gold is pressed off, and the gold amalgam remains.

SILVER AMALGAM.

In the preparation of silver amalgam, chemically pure silver, in a finely divided state, must be used, and the process is as follows:

Over broken silver is poured nitric acid, and the metal easily dissolves, with generation of dense, brown fumes, to a liquid, colored blue by the copper which is mixed with the silver. After this silver solution has been diluted with water and filtered, it is put into a thick-walled glass bottle, with a few pieces of sheet copper, and repeatedly shaken. As soon as the copper has been put into the liquid it begins to be coated with a layer of very finely divided silver, which, thrown back into the solution by the shaking, is soon renewed, and after a short time all the silver is separated in this finely divided state. The powder is washed in the liquid, poured upon a filter, where it remains as a gray powder with metallic luster, and then washed with distilled water until the water which has run off is no longer colored blue by adding ammonia—an indication that no more copper is present. Finally the silver powder is dried.

Silver amalgam is very easily prepared from this finely divided silver; the mercury needs only to be heated to 250 deg. to 300 deg. C., the silver powder shaken in, and mixed with the mercury by stirring. After heating for a few minutes, the vessel is allowed to cool, and the granular crystalline amalgam is separated from the excess of mercury by pressing in a leather bag.

Silver amalgam is also easily prepared by dissolving silver in nitric acid, evaporating the solution until the excess of free acid is removed, diluting with distilled water, and introducing into the liquid four parts by weight of mercury for each one part of the silver originally used. The mercury separates the silver in a metallic state, and at once unites with it to an amalgam. The liquid above it will contain, after a time, no more silver, but will be a solution of mercurous nitrate, with which is mixed any copper which was present in the silver in the form of copper nitrate. To tell whether all the silver is separated and united in the amalgam, try a sample of the solution with a few drops of hydrochloric acid; if there is no white, cheesy, precipitate, the silver is all amalgamated.

TIN AMALGAM.

Among the amalgams of the non-precious metals, only tin amalgam is of importance for plating purposes, being used for small objects and for coating glass in making mirrors.

The process of preparing tin amalgam is simple. The mercury is heated, and thin sheet tin (tin foil) or tin filings put into it. To produce an amalgam suitable for small optical mirrors, one part of tin for four parts of mercury is used, and the glass, previously heated, is pressed into the amalgam in such a way that no bubbles of air can remain between it and the amalgam. After cooling, the amalgam will be found to adhere very firmly to the glass, and to make a fine mirror.

In preparing any amalgam, or in working with it, especially in fire-gilding or silvering, it must be remembered that mercury is a very poisonous metal, and that the fumes from it are extremely injurious. It must be made a rule that all work where mercury fumes are developed, which is the case in making the amalgams and in fire-gilding, should be performed beneath a chimney with a strong draft of air, so that the fumes may be at once led away from the work room.

THE AMALGAMATING SOLUTION.

The so-called amalgamating water, or mercurial solution, is used for giving to articles which are to be gilded or silvered in the fire a thin coating of pure mercury. Chemically speaking, this is mercurous nitrate, and is prepared as follows:

The mercury is put into a porcelain vessel, and nitric acid poured over it, but not a sufficient quantity to dissolve all the mercury. On gentle heating, brown fumes are generated, and the mercury is dissolved and separates, in cooling, in yellow crystals. Water and more nitric acid are added to the fluid, which is then heated until all the crystals are dissolved and put into a bottle, into which enough mercury has previously been poured to just cover the bottom.

One special formula for making the mercurial solution requires 11 parts of nitric acid, density 1.33, for 10 parts of mercury, and 540 parts of soft water (rain) added to the fluid after the solution of the mercury.

If zinc, copper, bronze, or brass is immersed in this amalgamating fluid, a coating of metallic mercury, which reflects like a mirror, is deposited upon the surface of the objects, which is then ready for fire-gilding, the metals being "amalgamated." The fluid is caustic and poisonous, and one must avoid touching it with the hands.

Another purpose for which this amalgamating fluid is used is to give brass a dark bronze surface, and it is also employed in gilding porcelain.—Translated from "Das Verzinnen, Verzinken, etc., der Metalle."

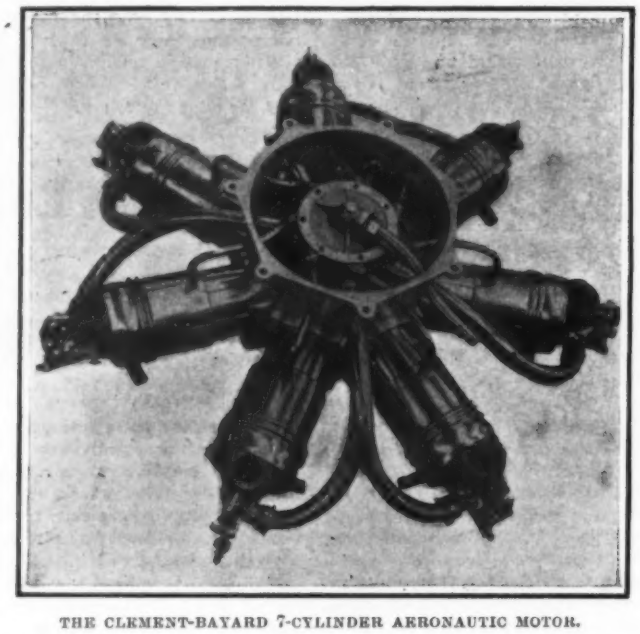
FOREIGN AERONAUTIC MOTORS.—II.

DESCRIPTION OF SOME OF THE LIGHTEST OF THOSE OF THE CIRCULAR OR REVOLVING-CYLINDER TYPE.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

THE FARCOT CIRCULAR AIR-COOLED MOTOR.

ONE of the light-weight motors, a photograph of which was reproduced in our issue of last week, is the circular air-cooled Farcot engine, some of the details of which are shown on the opposite page. This motor is the invention of M. Ambroise Farcot, a well-known French motor designer.



THE CLEMENT-BAYARD 7-CYLINDER AERONAUTIC MOTOR.

This view shows the under side of the motor, the cover of the case being removed to show the pump.

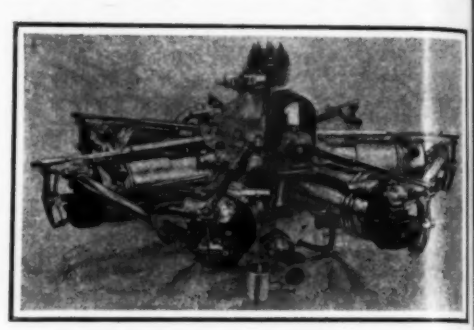
In constructing his latest light-weight motor, M. Farcot has sought to obtain lightness in two ways, namely, by grouping all the cylinders around the crankshaft, and by making them air-cooled by means of ordinary heat-radiating flanges.

This arrangement of cylinders grouped symmetrically around a central crank case is not by any means a new one, it having been used by Mons. F. Forest in 1888, and by Charles M. Manley in 1900, when constructing motors for aeronautic purposes. The former of these two gentlemen produced a 50-horse-power 8-cylinder motor of this type having cast-steel cylinders with heat-radiating flanges, the total weight of which was 551 pounds (11 pounds per horse-power); while the latter built a 52-horse-power 5-cylinder water-cooled motor of but 125 pounds weight (2.4 pounds per horse-power) that ran continuously under load for 10 hours, and developed its full horse-power, and which was subsequently used by Prof. Langley in his full-sized aeroplane. The number of cylinders and their arrangement in a motor of this type have much to do with the balance, the regularity of cycle, and the smoothness of running and lack of vibration. Such a 4-cylinder motor is nearly balanced as far as centrifugal force is concerned, and the little that it is lacking can be made up by a suitably-placed counterweight. With two sets of 4 cylinders working upon two cranks set at 180 deg., the balance is better still—the more so the nearer together the planes of the two sets of cylinders.

The plan-view diagram shows the arrangement of the eight cylinders about the crank case, and the method of attaching the two sets of connecting rods to the two cranks. Four of the cylinders are necessarily in a different plane from the other four, in order that their connecting rods can be attached to the second crank, but by strongly offsetting the rods it has been possible to reduce the distance between the planes of the two sets of cylinders to about one inch (25 millimeters). The two cranks are set at 180 deg., and alternate cylinders are set in different planes. As the crankshaft is set vertical, a horizontal shaft, driven by bevel gears at a somewhat reduced speed, is located near the top of the crankshaft for the purpose of driving the propeller. Ball thrust bearings take up the thrust of the bevel gears, while the crankshaft revolves in three bearings—one at the bottom (which carries the weight of the crankshaft), one in the upper part of the conical casing that covers the bevel gears, and one at the extreme top of this casing, where the crankshaft protrudes and the fan is attached. The bottom end of the crank case, and also two opposed cylinders of the lower four, are provided with brackets upon which they rest, and which serve to attach them to a suitable foundation. A magneto can also be fitted to the base plate, and arranged so as to be gear-driven from the crankshaft.

One of the notable features of the Farcot motor is the use of a single poppet valve (in connection with a sliding tube) for both inlet and exhaust. A good idea of this valve is to be had from the two diagrams showing it in the inlet and exhaust positions. The valve first opens a certain amount, and allows the exhaust gases to be expelled through the chamber surrounding it, which is covered with a perforated casing. The valve is then opened somewhat farther, until the ring of holes in the tube surmounting it is below the bottom of the stationary tube leading from the carbureter. The suction through these holes is sufficiently strong for the descending piston to draw in a charge of gas, even though it has an opportunity to aspire some of the outrushing burned exhaust gas also. As a matter of fact, however, probably only practically pure air is drawn in through the exhaust, as the inertia of the outrushing charge should be enough to thoroughly clear the chamber, while besides this the perforations in the casing would have a retarding effect, tending to check too great an inrush of air when the motor is on the suction stroke. The valve arrangement shown makes it possible to force mixture into the cylinder under pressure should this be desirable, but ordinarily one carbureter for each pair of cylinders can be made to supply a sufficiently rich mixture.

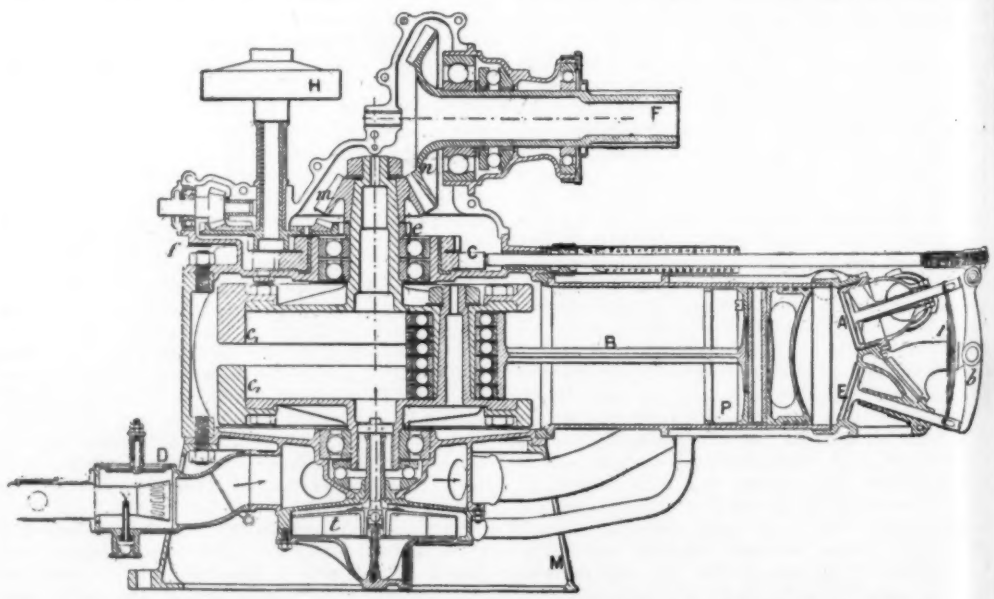
The lubrication of the Farcot motor is accomplished by means of a gear pump that forces oil through the hollow crankshaft, whence it exits through holes leading to the connecting rods, and thus giving a thorough force-feed lubrication. Double high-tension ignition, consisting of two magnetos and a spark coil and battery, is fitted. The magnetos are very small, and are driven by bevel gears. The gears are meshed so that one magneto is set one quarter turn behind the other as to the maximum points of current generation.



CLEMENT MOTOR COMPLETELY ASSEMBLED.

The carbureter is seen at the bottom, the distributor at the top, and the magneto just above the cylinders in the center. The valve-operating levers operated by flat springs are also visible.

Owing to the construction described, it has been found possible to reduce the weight of the Farcot motor to 1 kilogramme (2.2 pounds) per horse-power. This includes the double ignition system above mentioned (which weighs complete only 15 pounds), the four carbureters, the fan, oiler, etc. The eight-cylinder type of motor is made in three different sizes, of 30, 50, and 100 horse-power respectively. The cylinder dimensions of the 30-horse-power motor are 80x90 millimeters (3.149x3.543 inches), the total weight being 38 kilogrammes (83¾ pounds), and the normal speed is 1,800 R.P.M. The 50-horse-power motor has 105-millimeter bore by 120-millimeter stroke (4.133x4.724 inches), and runs at a normal speed of 1,400 R.P.M., its weight being 55 kilogrammes (121 pounds). The 100-horse-power size has a 130-millimeter bore by 135-millimeter stroke (5.118 x 5.314 inches), and 110-horse-power is claimed for it at a speed of 1,200 R.P.M. The further claim is made for the 50-horse-power motor that it will develop as high as 70 horse-power for a short



CROSS-SECTION OF CRANKSHAFT AND ONE CYLINDER OF THE CLEMENT 7-CYLINDER MOTOR.

B, Connecting rod; P, piston; A and E, inlet and exhaust valves; C, central cam working the valve rocker lever, b; c_1 c_2, balancing counterweight; D, carbureter; H, distributor; F, horizontal shaft for driving propeller; M, aluminium base; t, centrifugal water pump.

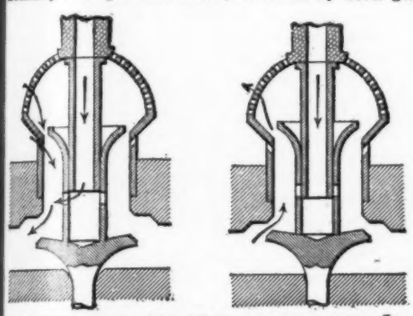
FOREIGN AERONAUTIC MOTORS OF THE CIRCULAR TYPE.

time. It is very doubtful, however, if an air-cooled motor of this type can be run successfully at this speed for any length of time.

THE CLEMENT CIRCULAR WATER-COOLED MOTOR.

The new Clement aeronautic motor, which was designed by M. Clerget of the Clement Company, resembles the Farcot motor in general shape, but in details it is somewhat different. It has seven water-cooled cylinders, all in the same plane, and the connecting rods of which are attached to a single crank. A double counterweight, which acts as a flywheel, makes the motor well nigh perfectly balanced. The arrangement of horizontal cylinders arranged radially around a central crank case was adopted in order to reduce to a minimum the number of parts, and also so as to allow of the use of a reliable oiling system and an efficacious water circulation.

Although constructing a high-speed motor of the lightest weight possible, M. Clerget sought to reduce the speed of the propeller shaft to that used in ordinary practice. This shaft, which is placed horizontally on top of the motor, is driven by bevel gears



THE SINGLE VALVE OF THE FARCOT MOTOR IN INLET AND EXHAUST POSITIONS.

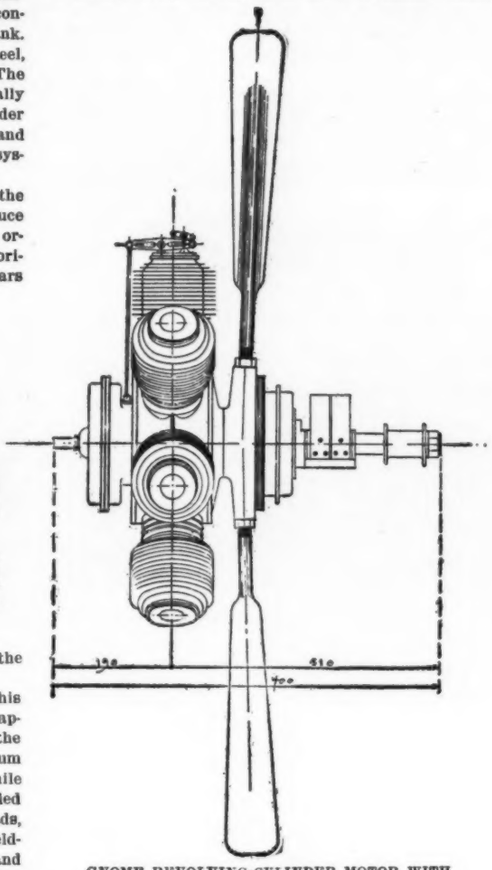
from the crankshaft at about 800 R. P. M., while the motor ran normally 1,200 R. P. M.

The photographic and cross-sectional views of this motor which we reproduce give a good idea of its appearance and construction. In order to obtain the maximum lightness, the thickness of the aluminium parts even was reduced to the extreme limit, while the cylinders were made of a special steel, rectified after a particular treatment. The cylinder heads, of cast steel, are screwed upon and afterward welded to the cylinders. This method of making and attaching the cylinder heads does away with many small and unnecessary parts. The valves are in the heads. They are operated by the rocker arms, *B*, while a single flat spring, *R*, holds them against their seats. The rocker-arm push rods also have coiled springs. *A* is the indet valve, and *B* the exhaust valve. *A* can readily be removed by unscrewing its seat.

The pistons, of pressed steel, have depressed heads, the result being that the general shape of the combustion chamber is ellipsoidal, which makes for thermal efficiency. They have three rings each, and are very light.

The crankshaft is of a special steel, cemented and tempered and afterward rectified. The crank pin is removable, to allow of the slipping in place of the sleeve, to which all the connecting rods are attached. It also carries the two counterweights. There are three principal connecting rods, to which the other four rods are attached. These three principal rods are each carried upon two sets of balls, one upon the two inner rings, and the third upon the intermediate pair.

The operation of the valves of the motor is effected by means of a single central cam; this cam is geared down so that it revolves at one-eighth the speed and in the same direction as the crankshaft. There are four high points and four depressions, which correspond respectively to the opening of the exhaust and inlet valves. The arrangement of such a cam revolving at only one-eighth the speed of the crankshaft makes it possible to operate the valves with very little wear upon the mechanism. The occurrence of the exhausts regularly every two-sevenths of a revolution apart



GNOME REVOLVING-CYLINDER MOTOR WITH PROPELLER ATTACHED TO ITS CRANK CASE.

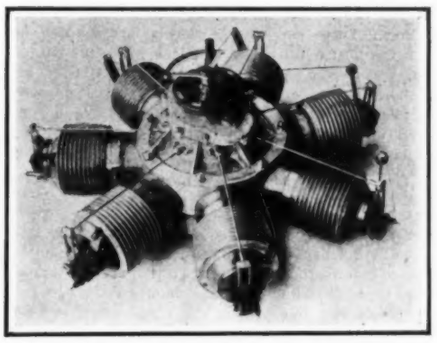
causes the motor to run very smoothly indeed. The distributor for the spark plugs is run at half the speed of the motor. The high-tension magneto is driven directly from the crankshaft, and the current passes from it to the distributor, which is placed vertically near by. The carbureter, which is located beside the crank case and is connected by a short pipe to the central chamber in which all the inlet pipes terminate, has a spray nozzle, a diffuser, and an automatic auxiliary air valve. Means are also provided for obtaining warm air for the carbureter.

The arrangement of the water-circulating pump around the crankshaft, as shown in our illustration, is a novel one, and one that makes sure the proper cooling of all the seven cylinders. The water is pumped to the bottom of the water jackets, and makes its exit at the top of the cylinders, whence it goes through the radiator. A special radiator having 3 square meters (32¼ square feet) of surface is employed. This radiator, in addition to its reservoir of water, weighs only 12 kilogrammes (26½ pounds). The water jackets are of copper, soldered and clamped in place.

The bore of the cylinders is 110 millimeters (4.33 inches), and the stroke of the pistons is 115 millimeters (4.527 inches). The motor develops 50 horse-power at its normal speed of 1,200 R.P.M. This speed is by no means excessive, and the piston speed is normal. Consequently, there seems to be no reason why this motor should not operate perfectly for hours at a stretch. The diameter of the motor is about 3 feet, and its total weight in working order with all accessories is only 70 kilogrammes (154.32 pounds) or 3.08 per horse-power. Thus, in general outline and in weight per horse-power also, this motor resembles closely that built by Mr. Manley for Prof. Langley's aeroplane in 1900. The first of these motors will be used upon a monoplane that M. Clement has had constructed, and which was exhibited at the recent Paris Aeronautic Salon.

THE ADAMS-FARWELL AND GNOME REVOLVING-CYLINDER MOTORS.

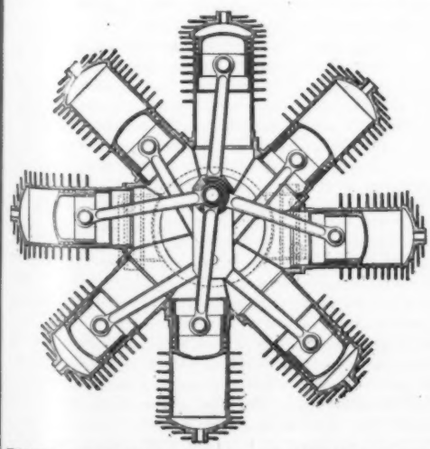
Revolving-cylinder motors, in which the cylinders are arranged radially about a central crank case, and are made to revolve around a stationary crankshaft, have been on the market for several years. One of



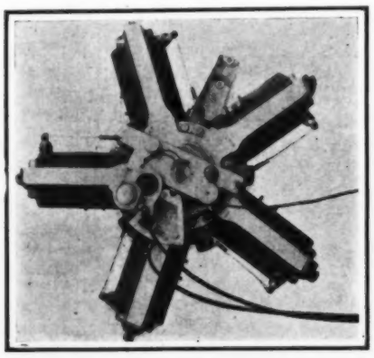
GNOME 50-HORSE-POWER REVOLVING-CYLINDER MOTOR.

the first of these to be regularly manufactured for use in automobiles was that brought out in America by the Adams-Farwell Company, and has been the subject of considerable experiment by at least one distinguished inventor. Since then the makers have brought out a very light aeronautic motor of 4¼ inches bore and 3½ inches stroke and of but 98 pounds weight, which they claim will develop 36 horse-power at 1,800 R.P.M.; and also a 55-horse-power 5-cylinder motor weighing 150 pounds, and developing its power at 1,200 R.P.M. The smaller of these two motors is illustrated herewith, as is also a French motor of similar design called the "Gnome," which has recently been brought out by a well-known stationary and marine gas engine firm in France. While the Adams-Farwell motor originally had heat-radiating flanges on its cylinders, Mr. Farwell has found that it is possible to dispense with these, and to use a perfectly smooth cylinder. The "Gnome" motor, on the other hand, retains the usual type of flanged cylinder used on most air-cooled motors. It has combined inlet and exhaust valves similar to those used on the R.E.P. motors, and the carbureter is placed at the bottom of the hollow crankshaft through which the gas is fed. The oiling is accomplished largely by centrifugal force, which distributes the oil thoroughly over the cylinders. This motor is very well balanced, the revolving cylinders acting as a fly-wheel. As a result, this type of motor can be built very light; it generally weighs about 3 pounds per horse-power. The Société Gnome is building a 7-cylinder motor of 50 horse-power and a 14-cylinder motor of 100 horse-power, the bore and stroke of both motors being 110 millimeters (4.33 inches) and 120 millimeters (4.724 inches) respectively. The normal speed of these motors is 1,200 R.P.M.

The novel feature about the Adams-Farwell motor is the valves, which are placed side by side in the cylin-

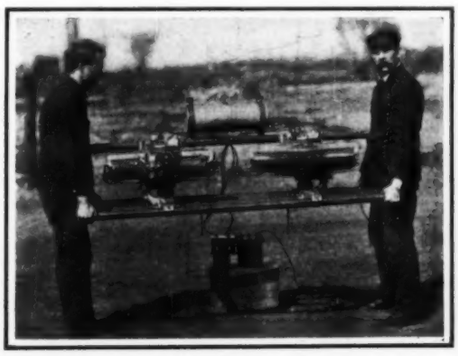


HORIZONTAL CROSS-SECTION OF THE 50-HORSE-POWER FARCOT AIR-COOLED MOTOR.



PLAN VIEW OF ADAMS-FARWELL REVOLVING-CYLINDER MOTOR.

The above view shows well the simplicity of this type of motor.



A STATIONARY AND A REVOLVING ADAMS-FARWELL MOTOR HELD BY TWO MEN.

The man at the right is Mr. Farwell, the inventor.

FOREIGN AERONAUTIC MOTORS OF THE CIRCULAR TYPE.

der heads, and are closed by centrifugal force. The inlet valve is automatic, and thus but a single push rod for each cylinder is needed to operate the exhaust valve. In opening this valve, the rocker arm which moves it fulcrums against the stem of the inlet valve and holds it closed. Similarly, when the inlet valve is opened by the suction of the motor, it is held tightly against its seat. A special form of force-feed oiler, of very light construction, is mounted at the upper end of the crankshaft, and forces the oil through this shaft to the connecting rods. Centrifugal force spreads it thoroughly over the pistons. An ordinary float-feed carbureter, of very small dimensions for the size of the cylinders which it has to supply, is located in the aluminium casing above the crank case. This casing is connected to the inlet valves of the various cylinders by square-shaped aluminium pipes placed on top of the cylinders. The current for the spark plugs is taken from a stationary sector above the crank case, through wires running along the cylinders to the plugs. There is a slight gap between the inner end of the wire and the sector, which the spark jumps without difficulty. These motors are now being produced in either the horizontal or the vertical type; but one of them, which has come under our observation in an aeroplane, has not worked satisfactorily, and it appears that there are several points which must yet be improved upon before the motor can be perfected for aeroplane use.

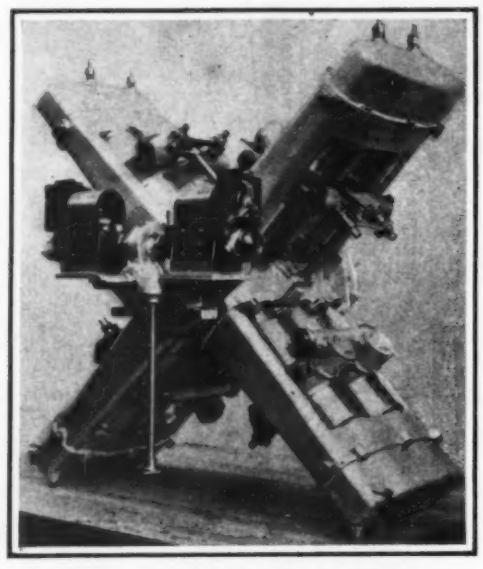
THE GOBRON-BRILLIÉ X MOTOR.

One of the most interesting motors of the recent Paris Aeronautic Salon was that exhibited by the Gobron-Brillié firm. This motor, besides its peculiar shape, is noteworthy because it is of the special double-piston type, in which the explosion occurs between two pistons and drives them apart, the effort exerted upon each piston being transmitted to the crankshaft by means of connecting rods. In 1903 M. Gobron had a 120-horse-power motor of this type, weighing only about 6½ pounds to the horse-power, in one of the Paris-Madrid racing autos. The new aeronautic motor shown herewith weighs 150 kilogrammes (330 pounds) and gives 75 horse-power, or 1 horse-power for every 4.4 pounds weight. There are eight cylinders arranged in X shape, and each containing two pistons. The central crank case contains the two-throw crankshaft, each crank of which carries the connecting rods of four cylinders. There are no gears nor cam shafts, and the inlet valves are all automatic.

A glance at the diagrams will show the main features of this motor. The one at the right shows the pistons *Ps* and *Pi*, while the explosion chamber is shown at *G*. The main connecting rods, which can be seen in both cross sections, are marked B_1, and the two outside connecting rods for the outer pistons, B_2. Yokes *E* connect the rods to the bodies of the outer pistons, which have no wrist pins.

The exhaust valves are shown at *s s*, and the inlet valves at *d*. The central cam *C*, which will be mentioned later, operates, through the levers *t t* and the shafts *a a*, the exhaust valves by means of rocker arms *e e*.

The action of the valve is as follows: Above the exhaust valves of each group is placed a double rocker arm, which, at each turn of the shaft, opens one or the other of the two valves. In order to obtain this movement, each of the rocker arms, *e*, is fastened to a shaft, *a*, that is given a reciprocating movement by a lever, *t*, attached to its other end. On the end of *t* is a shoe or follower that runs in one or the other of two grooves in the double cam, *C*, which is keyed to the crankshaft. The two grooves meet at one point, and the shoe is switched thus from one side to the other of the double cam in order to operate alternately the two exhaust valves in each pair of adjoining cylinders. This arrangement, although composed of very strong pieces, is naturally very light. As the inlet



GOBRON-BRILLIÉ DOUBLE-PISTON MOTOR.

There are 8 cylinders, each of which has two pistons that are driven apart by the explosion.

valves are automatic, they can be made quite light also. All the valves are very accessible.

The single carbureter is placed between the lower cylinders. This carbureter can be throttled, in order to run the engine at a reduced speed. It is of the ordinary automatic type used on Gobron motors. The inlet pipes are so arranged that the course followed by the gas from the carbureter to any one cylinder is precisely the same.

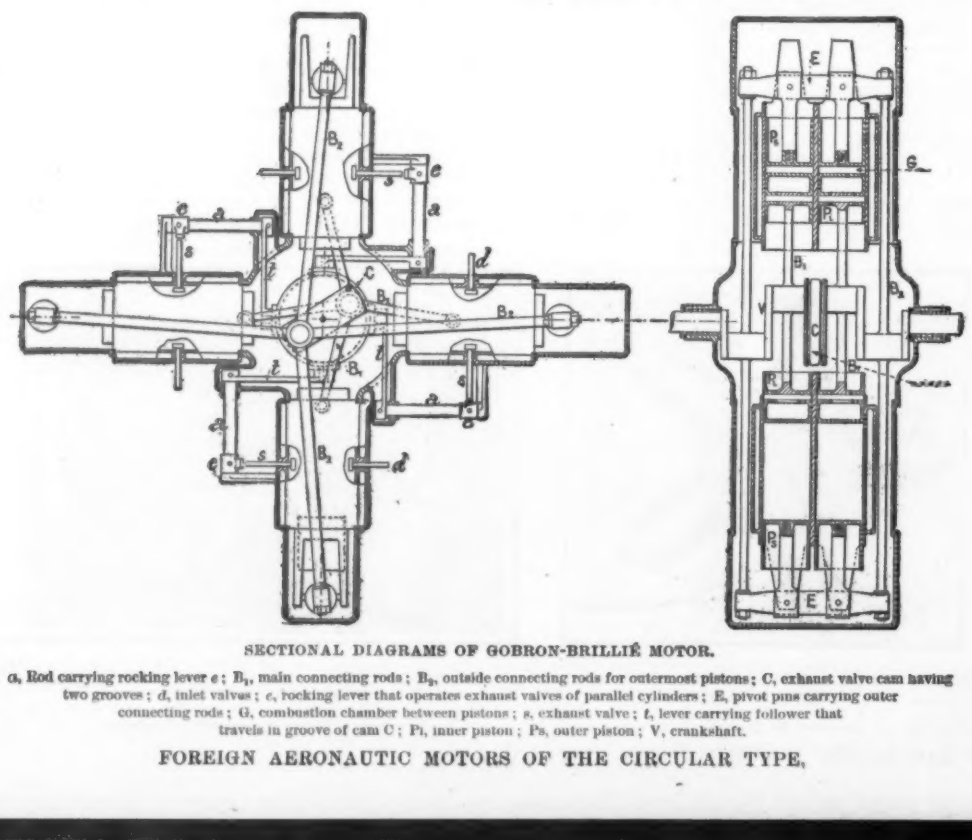
The ignition is by means of two magnetos placed on a shaft beside the crank case. They are driven by means of worm gears arranged at right angles, and they turn in opposite directions.

The water circulation is obtained by means of a large centrifugal pump fastened directly at the top of the vertical shaft seen in the photograph. The cylinders are provided with liberal water jackets, and the delicate parts, such as the valves and spark plugs, are surrounded by water as much as possible.

A special form of radiator is used, the quantity of water necessary being only about 4 gallons.

The lubrication is accomplished by means of a gear pump, which raises the oil from the crank case of the lower cylinders, and forces it into the upper cylinders. All the movable parts are thoroughly lubricated. The oil pump, like the magnetos, is driven by worm gears running in oil.

This motor, as can be seen from the above description, is one of the lightest water-cooled engines thus far produced. The principle upon which it is constructed is one that has been well tried out in automobiles, and there seems to be a reasonable probability that this type of motor will operate successfully in an aeroplane.



SECTIONAL DIAGRAMS OF GOBRON-BRILLIÉ MOTOR.

a, Rod carrying rocking lever *e*; B_1, main connecting rods; B_2, outside connecting rods for outermost pistons; C, exhaust valve cam having two grooves; *d*, inlet valves; *e*, rocking lever that operates exhaust valves of parallel cylinders; E, pivot pins carrying outer connecting rods; G, combustion chamber between pistons; *s*, exhaust valve; *t*, lever carrying follower that travels in groove of cam C; Pi, inner piston; Ps, outer piston; V, crankshaft.

FOREIGN AERONAUTIC MOTORS OF THE CIRCULAR TYPE.

AERONAUTICAL TERMINOLOGY.

By JOHN H. LEDEBOER.

IT is one of the great disadvantages of a new science, that it creates a distinct technical terminology of its own, which, in its infancy and in its rapid youthful growth, tends to become a source of the greatest confusion. Aeronautics is a case in point. The startling developments that have taken place of late years in every branch of aeronautical research and endeavor have called into the world a host of words which are only too often misapplied and misunderstood. In other cases, again, an inventor is tempted to coin words which are as barbarous as they are misleading, in the endeavor to express some object or function for which a concise name is, as yet, lacking.

It is here attempted to unravel a skein which is daily becoming more tangled, and to restore to each term its distinct and distinctive meaning.

AERONAUTICS, in the first place, comprises aerial navigation in its entirety, without special reference to any of its branches. It may be divided into:

AEROSTATICS, the science of aerial navigation by means lighter than the air, and

AVIATICS, the science of aerial navigation by means heavier than the air. AEROSTATION and AVIATION refer respectively to the practice of these two branches.

AERODROMICS is equivalent to AVIATICS. (See AERODROME.)

Taking the first of these divisions:

AEROSTAT refers to an ordinary spherical balloon;

AERONAT is a dirigible, motor-driven balloon, or airship.*

In the second, or heavier-than-the-air, division:

AEROPLANE denotes a dynamic flying machine sustained by the reaction of the air on one or more planes, propelled by propellers or similar means. The term is an unfortunate one, as it is sometimes, and justifiably, used to denote the sustaining surface alone, and as the so-called aeroplane usually comprises curved surfaces. The name has, however, become hallowed by popular use.

HELICOPTER denotes a flying machine consisting of one or more lifting screws with a more or less vertical axis.

ORNITHOPTER denotes a machine in which the means of sustentation and propulsion consist of beating wings. (ORTHOPTER is misleading and should not be employed.)

AERODROME (an *air runner*), first used by Prof. Langley, is the most suitable and comprehensive word to denote a flying machine of any kind. It should never be used in the meaning of a "balloon shed." The word AERODROMICS, derived hence, may be applied to the whole science of free flight.

AEROFOIL has been proposed by F. W. Lanchester to denote the sustaining surface in a flying machine, the spread wing of a bird, etc.

AERODONE, proposed by the same authority to denote a motorless flying machine—a glider.

In conclusion, the use of such barbarous and utterly misleading expressions as "Aviplane" (referring to an ornithopter) and "Aviator" (when applied to the flying machine instead of to the man who mounts it, the operator) cannot be too strongly deprecated.

It is, of course, quite possible that the majority of the terms cited above may cease to be employed at all, or may receive a slightly different application, in years to come when aerial navigation has become an every-day means of locomotion. But by that time the fertile brain of the man in the street will surely have evolved a whole range of concise expressions which will replace our somewhat cumbrous scientific terms. In the meantime, however, we must perforce content ourselves with these.—Aeronautics.

A dispatch from Montreal states that the Grand Trunk Railway has under consideration an entirely new terminus scheme for Montreal involving a cost of some millions of dollars. The new scheme, which is being designed under the direction of the new chief engineer, is of a twofold character, one feature of it being the construction of an air-line from the bridge to Bonaventure Station, with an appropriate terminal structure there, and the other the quadrupling of the track from beyond St. Henri to give a double track for both passenger and freight traffic from the West.

* "Airship" should never refer to a flying machine—a contrivance heavier than air.

PRACTICAL THERMODYNAMICS.

STEAM ENGINE EFFICIENCY IN THE LIGHT OF MODERN MECHANICS.

THE last fifteen years have marked a noteworthy change in the meaning commonly attached to the thermodynamic efficiency of a steam engine. Up till a very few years ago such efficiencies were estimated by comparing the total work done with the total expenditure of heat, a procedure which led to the somewhat disheartening result that, reckoned on this basis, the efficiency of the very best steam engines did not exceed some 18 per cent or so. In practice the coal consumption, reckoned in pounds per horse-power-hour, was, and to a large extent still remains, the customer's criterion of efficiency, but suffers from the drawback of not apportioning the total losses between the boiler, the engine, and, in these days of turbine and high vacua, we should, perhaps, add the condenser. Electric power station engineers were the first, as a body, to appreciate the importance of separating the boiler and engine losses. Thirty years ago few engine builders were prepared to guarantee steam consumptions, though they had a fair general idea as to the fuel needed per horse-power-hour. As standards of efficiency rose, however, builders recognized the necessity of protecting themselves from losses due to bad stoking, bad boilers, or other causes not under their direct control; while station engineers, to insure low generating costs, found it essential to separate questions of boiler efficiency from those inherent in the design and construction of the engine, and hence guarantees as to steam economy are now as common as they were rare thirty years ago.

The late Mr. Willans was, we believe, the first manufacturer to appreciate the advantages of referring questions of engine efficiency to the efficiency of an ideally perfect steam engine working under corresponding conditions, in place of to the absolute standard already referred to, which ignores the inherent imperfections of all heat engines. Referred to this standard, however, non-condensing engines showed themselves markedly superior to the condensing type, in spite of the lower steam and fuel consumption recorded with the latter. This paradox occasioned some difficulty to those who failed to realize the very ineffective use which the reciprocating engine is able to make of its condenser. This practically insuperable defect became startlingly obvious with the introduction of the condensing steam turbine. Worked non-condensing the steam turbine is notably inferior in its performance to the best reciprocating engines, but the addition of a condenser placed it at a single bound at the head of the list. Nevertheless, some station engineers still fail to appreciate the all-importance of preventing air leakage into condensers for turbine machinery. On not a few occasions complaints to builders that the steam turbine was failing to maintain its initial economy in the matter of fuel have turned out to have arisen solely through a neglect to stop air leakage into the condenser. Station engineers have not uncommonly been drawn from the merchant marine, a choice which experience has thoroughly justified. With the ordinary marine engine, however, the difference in the fuel consumption, corresponding to the use of a 26-inch in place of a 28-inch vacuum, is almost immaterial, being about 1 per cent or so, while with a turbine a reduction of 2 inches on a 28-inch vacuum sends up the consumption by 11 to 12 per cent. Even now, this difference between the two types of prime mover is not always realized.

The introduction of the steam turbine has, nevertheless, done much to popularize the idea that in heat engines only a portion of the heat energy added to the water in the boiler is "available" for the production of mechanical work, but difficulties are still experienced in endeavoring to attach a satisfying physical meaning to entropy. In his recent presidential address to the Institution of Junior Engineers, Mr. James Swinburne points out that in certain cases, at any rate, an increase of entropy corresponds to an increase either in the "range" or the "intensity" of the molecular motion of a gas. If a gas is expanded isothermally, the average velocity of its molecules is unaltered, but their "range" of movement is increased, the mean free path being greater than before the expansion. Since heat has been added the entropy has also been increased, so that in this case the change of entropy has been coincident with an increase in the range of the molecular motion. If, on the other hand, a gas is heated at constant volume, this range of movement is unaltered, but the velocity of the motion is increased, so that here the augmentation of entropy corresponds to an increase in the intensity of the molecular motion. In adiabatic expansion, on the other hand, the increase in "range" is exactly compensated for by the decrease in "intensity."

Perhaps the easiest method of picturing a growth of entropy is furnished by Joule's famous experiment, in which air compressed into one vessel is suddenly allowed to expand through a stop-cock into another originally vacuous. After equilibrium is established the temperature of the gas is found to be unaltered; but the entropy has been greatly increased. It is sometimes claimed that in such a case no heat has been added during the expansion, and that therefore there should have been no increase in the entropy. As a matter of fact, this idea is incorrect. The initial stage of the process, viz., the rush of the gas through the stop-cock, may take place nearly adiabatically, and the jet, accordingly, issues with a considerable velocity. Since such a velocity has a definite direction, the jet of gas is possessed of high-grade energy, which, under suitable conditions, could be employed in accomplishing mechanical work. At the end of the operation, however, when the steady state has been obtained, this "directed" velocity of the jet, as a whole, has been wholly converted into a random motion of the individual molecules, or, in other words, has been returned to the gas in the form of heat.

In all the instances given above it is possible to associate certain physical changes, easily visualized, with the growth of entropy; but these physical changes appear to be rather concomitants with the increase of entropy rather than this increase itself. It is easy, indeed, to find cases in which the growth of entropy has no connection with a change either in the range or the intensity of the random motion of the molecules of a system, when that system is considered as a whole. Thus if heat flows by conduction from one portion of a gas to another, neither the range nor intensity of the random motion of the molecules, taken as a whole, is altered, since the random kinetic energy lost by the hot portion is gained by the cooler portion. The entropy has, however, increased, but the only net physical change has been an increase in the uniformity of the total mass.

There is some reason for believing that every lack of uniformity in Nature constitutes a source of high-grade energy. If the chemical atoms are unstable, as some assert, the energy liberated in their break-up is undoubtedly high-grade, but is ultimately degraded into heat. If this hypothesis of atomic disintegration be correct, the ultimate end of the universe will be reached when the whole of the atoms now in existence have completely broken up, and all parts of space are uniformly filled with the fragments, all of which are identical *inter se*. The entropy will then be a maximum.

Since so many different physical processes are associated with changes in entropy, it seems useless to try and identify entropy with any particular one, and the concept should be taken as merely a mathematical convenience associated with, but not constituted by, many different physical changes. Its usefulness to those engaged in practical application of thermodynamics is now generally recognized, and its numerical values are regularly tabulated in all the best steam tables.

In this latter connection it is interesting to note that all the tables now in common use are based upon the work of Regnault, executed some sixty years ago. The accuracy of this experimenter's determinations is now challenged, since the most reliable of modern experiments show considerable errors in Regnault's estimate of the total heat of steam. Thus in the Physical Review of last February Prof. A. Whitmore Smith gave a table of the latent heats of steam between 0 deg. and 100 deg. Cent., based upon a comparison of the most reliable modern experiments; and in the November issue of the Journal of the American Society of Mechanical Engineers, Dr. H. N. Davis extends the comparison to higher pressures, and concludes that the true total heat of steam is given in B. Th. U. by the value

$$H = 1150.3 + 0.3745\ (t - 212) - 0.00055\ (t - 212)^2$$

in place of Regnault's value—

$$H = 1091.7 + 0.305\ (t - 32).$$

At boiling point Regnault's value is 1146.6 B. Th. U., while the new formula gives 1150.3. At freezing point Regnault's value was 1091.7 B. Th. U., as against 1073.4 by the Davis formula. At 200 pounds pressure the two formulæ are practically identical, but at higher pressures Regnault's value is too large, the error being 5.2 units at 300 pounds pressure. The error is, it will be seen, a maximum at condenser temperatures. Comparing the new values with the old, it appears that efficiency ratios estimated by the latter are, however, very little affected even in the case of exhaust steam turbines. If such a turbine, taking steam at atmospheric pressure, and expanding it down to a 28-inch vacuum, had an efficiency ratio of 68 per cent, as calculated by the old figures, its true efficiency ratio would appear to be about 67.6 per cent, or about ½ per cent less. With high initial pressures the errors appear to be even smaller, so that there is no immediate necessity for scrapping existing tables.

Dr. Davis makes an interesting application of his equation for the total heat of steam, to fix the relative reliabilities of the values for the specific heat of superheated steam found by Messrs. Knoblauch and Jakob and by Prof. Carl Thomas respectively. It is easy to show that, having accurate total heats, and an accurate knowledge of the specific volume of slightly superheated steam, the specific heat of the latter at the saturation temperature can be calculated by the general principles of thermodynamics. Making such a calculation, Dr. Davis finds that his results are in very much better agreement with the Munich experiments than with those made by Prof. Thomas, which fail even to indicate the general trend of the curve in the neighborhood of the saturation line. The error is attributed to the presence of particles of moisture suspended in the steam during the tests made by Prof. Thomas. Messrs. Knoblauch and Jakob found that such particles could exist in the midst of slightly superheated steam for an appreciable time before being evaporated, and the requisite time for this to take place was not allowed in the experiments at Cornell. A description of the Munich experiments, the general reliability of which seems now well established, will be found in our issues of March 15 and April 12, 1907.—Engineering.

INDUSTRIAL ACCIDENTS.

MR. FREDERICK L. HOFFMAN, of the Bureau of Labor, Department of Commerce and Labor, has compiled some striking statistics concerning the subject of accidents to workingmen. The importance of this subject is apparent when it is considered that between 30,000 and 35,000 workmen lose their lives in accidents in the course of their employment in this country during a year. Statistics have been secured from official sources and from insurance experience which show that the accident liability to which American workmen are subject is indeed high. Census reports covering the years 1900 to 1906 show that out of over 1,000,000 deaths of males more than nine per cent were due to accident.

The liability of workmen to accidental injury or death is brought under five general classifications, including factories and workshops, electrical industries, mines and quarries, transportation by rail and transportation by water.

Of those employed in factories and workshops, probably the most exposed class is the workers in iron and steel. Of 8,456 accidents during the years 1901 to 1905, 4.1 per cent of the accidents to men employed in rolling mills resulted fatally.

According to industrial insurance experience, the fatal-accident rate of electricians and of electric linemen is excessive. Of 645 deaths of electricians, 14.7 per cent, and of 240 deaths of linemen, 46.7 per cent, were due to accidents.

In the anthracite mines of Pennsylvania State inspectors have found that during ten years there have averaged annually 3.18 fatal accidents for every 1,000 men employed, and the rate is even higher than this for certain specific occupations in the mines. That this rate is excessive is shown by comparison with the death rate from accident of 1.29 per 1,000 in the British coal mines.

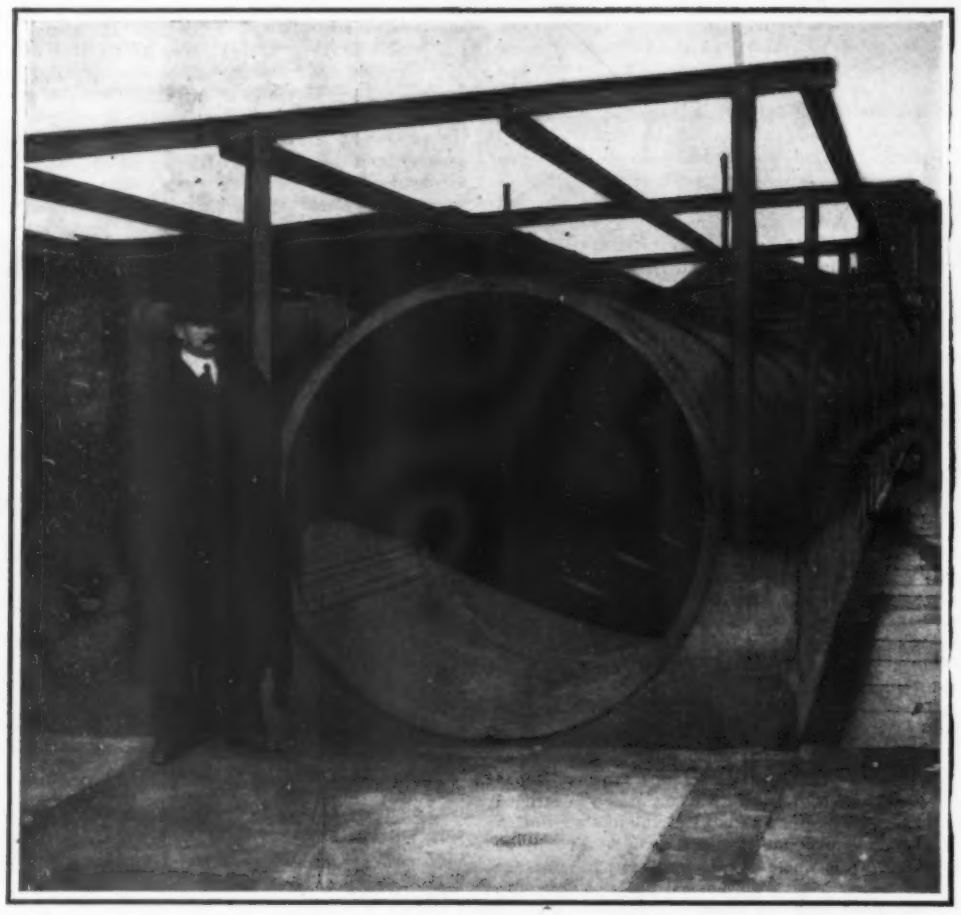
Reports of the Interstate Commerce Commission show that during ten years 16,363 railway trainmen lost their lives in accidents. This is equivalent to 7.46 deaths per 1,000 employees.

In a recent issue of the Illuminating Engineer, Mr. B. Dushnitz describes a new form of glow lamp that has been developed in Germany. The filament of the lamp is composed of carbon, but burns in an atmosphere of mercury vapor instead of *in vacuo*, as in the case of lamps of the ordinary variety. This atmosphere of mercury vapor is secured by the volatilization of a drop of mercury placed within the U-tube containing the filament. The lamp is said to consume about 1.5 to 1.7 watts per candle-power, and such results as are at present to hand regarding the life of the lamp are looked upon as satisfactory. The author quotes the results of a series of experiments by Dr. Lux, having for their object to determine whether the increase in efficiency is to be ascribed to high temperature or luminescence. The conclusion is reached that the former explanation is the correct one, the envelope of hot mercury vapor restricting the conduction of heat from the filament and so raising its temperature of incandescence.

THE PREVENTION OF MINING ACCIDENTS.

WHAT THE GOVERNMENT IS DOING TO SAVE LIFE IN MINES.

In its effort to stop the appalling loss of life in the coal mines of the country, the United States government is meeting with much success. For several months an experiment station, under the direction of the Technologic Branch of the United States Geological Survey, has been in operation at Pittsburg, Pa., with the purpose of discovering the causes of mine disasters and suggesting a remedy.



EXPLOSIVES CHAMBER WHERE EXPLOSIVES ARE TESTED IN PRESENCE OF COAL DUST AND FIRE DAMP.

Along with the establishment of this station and the agitation which preceded the necessary legislation, there has been a falling off in the number of deaths in the coal mines for the year 1908; and while the official figures have not yet been obtained, it is stated that the number of deaths will be several hundred less than in 1907, which was an unusual year. In December, 1907, four explosions took the lives of 700 men, one of them—at the Monongah mine in West Virginia—being the greatest mining disaster in the history of this country. There were 356 victims. During 1908 there were but two accidents in which the loss of life was very heavy; one in January at the Hanna mine in Wyoming, with a loss of 70 men; the other, November 28th, at the Marianna mine in Pennsylvania, which resulted in 154 deaths.

Two discoveries have been already made at the experiment station which will tend to decrease the number of deaths in the mines. It has been demonstrated that a number of the so-called "safety" explosives are anything but safe; in fact, the statement is made that with the present explosives used in mining, the miner takes his life in his hand every time he touches off a fuse. It is the purpose of the government to continue these experiments until the explosives of the country are standardized in such a manner that the miner will have a definite idea what these explosives will do.

After the government has gone far enough in its experiments, a bulletin will be issued recommending as permissible explosives such as stand the test. The facts learned concerning these explosives will be called directly to the attention of the State mining bureaus as well as the operators.

Perhaps the most important and far-reaching experiments so far at the station are those in which it has been definitely shown that coal dust is an explosive equally as dangerous as the deadly fire damp. This has been a moot question among mining engineers and miners alike, both insisting that it is impossible to explode coal dust unless there is gas present. That the coal dust will explode in a mine where there is no gas has been repeatedly shown to several hundred operators and miners at the testing station. The experts at the station are now bending their energies to discover some method by which this dust can be prevented from being a serious menace to the miners. Experiments in wetting it have been going on for some time, but nothing of a very definite nature has as yet been learned, unless it is the fact that the coal dust does not ignite when there is a great amount of moisture in it.

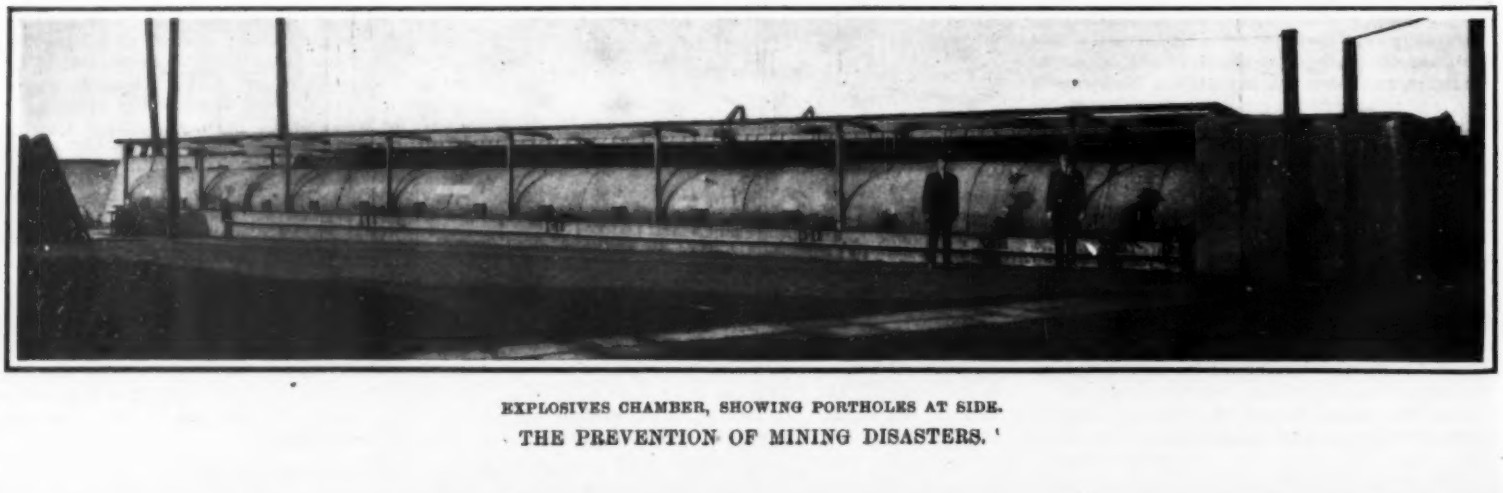
Every effort is being made at the station to come as close to the conditions in a mine as possible. The tests of various dynamites and powders used in blasting coal are being made in a mammoth boiler plate cylinder which has previously been filled with gas or coal dust. The cylinder is 100 feet long and 6 feet in diameter. Safety valves have been placed all along the top, and are left unfastened in such a manner that whenever there is an explosion the valves fly open on their hinges. A series of portholes on the side, covered with one-half inch glass, enables those conducting the experiments to witness the results from an observation house 60 feet away. An explosive mixture of fire damp and air, or coal dust and air, is pumped into the cylinder, and the explosive which is to be tested is shot into it from one end of the cylinder, so that the flame goes right into the fire damp or coal dust. Natural gas is used at this station for fire damp, because it corresponds very closely to this deadly gas. The cannon in which the explosives are placed is fired by electricity from the observation house, which is parallel with the cylinder itself.

These investigations are expected to accomplish a double purpose—not only a reduction in the number of men killed in the mines, but also a saving of the waste in mining coal. The use of improper explosives, as well as the improper use of suitable explosives, results annually in the waste of great amounts of coal. The use of too high charges in blasting, or the use of unnecessarily violent explosives, shatters much good coal, converting fuel into dust which may itself be explosive and become productive of much further damage. Such explosives often loosen the roof of a coal mine, which may fall later to be wasted, or productive of fatal accidents.

In addition to the actual experiments in testing explosives, important experiments are being made in rescue work. One part of the station has been fitted up as a miniature coal mine. This is a large glass-incased, air-tight room, which contains difficult passages such as are found in coal mines. There are also various obstructions similar to what would be found in a mine after it had been wrecked by an explosion; also dummies weighing 150 to 200 pounds, representing asphyxiated miners. This room is filled with deadly gas, and a rescue corps of men who are being trained in the work enter daily, clad in helmets which supply them with oxygen while they work. The men remain in this chamber for two hours, removing obstructions, picking up the dummies, placing them on stretchers and carrying them away. There is also in the room a machine which records the amount of work a man may be expected to do while wearing one of those helmets. One-half of the large building in which this rescue room is located is used as an auditorium, and several hundred miners and operators have watched the rescue drill through the large glass windows which separate the auditorium from the gas-filled chamber. Although there has been but little opportunity so far for the rescue corps to demonstrate its efficiency at the mines, still it has done some good work.

Once the helmeted men while fighting a mine fire succeeded in bringing an unconscious man to a place of safety, where he was given oxygen treatment and recovered his senses in a short time.

It is not the intention of the United States government to furnish rescue corps whenever there is a disaster. The present corps was organized with the idea



EXPLOSIVES CHAMBER, SHOWING PORTHOLES AT SIDE.

THE PREVENTION OF MINING DISASTERS.

of encouraging the mine owners and miners themselves to form such organizations. Invitations have been issued to operators throughout the country to send picked men to the experiment station, where they may watch the government rescuers at work and later go through the same training themselves, in order that they may gain the necessary confidence in the use of these helmets. Already a number of the large mining companies have taken advantage of this invitation, and are organizing rescue corps at their mines, fully equipped with oxygen helmets.

In 1907 more than 3,125 men were killed in the coal mines of the country—a death rate of 4.86 for every 1,000 men employed. This is from three to four times as many men per thousand as are killed in any coal-producing country of Europe, where experimental stations such as the one in Pittsburg have been in operation for several years.

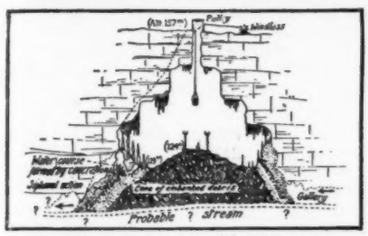
THE CAVERN OF PROUMEYSSAC.

THE REDISCOVERY OF AN ANCIENT NATURAL WONDER.

BY E. A. MARTEL.

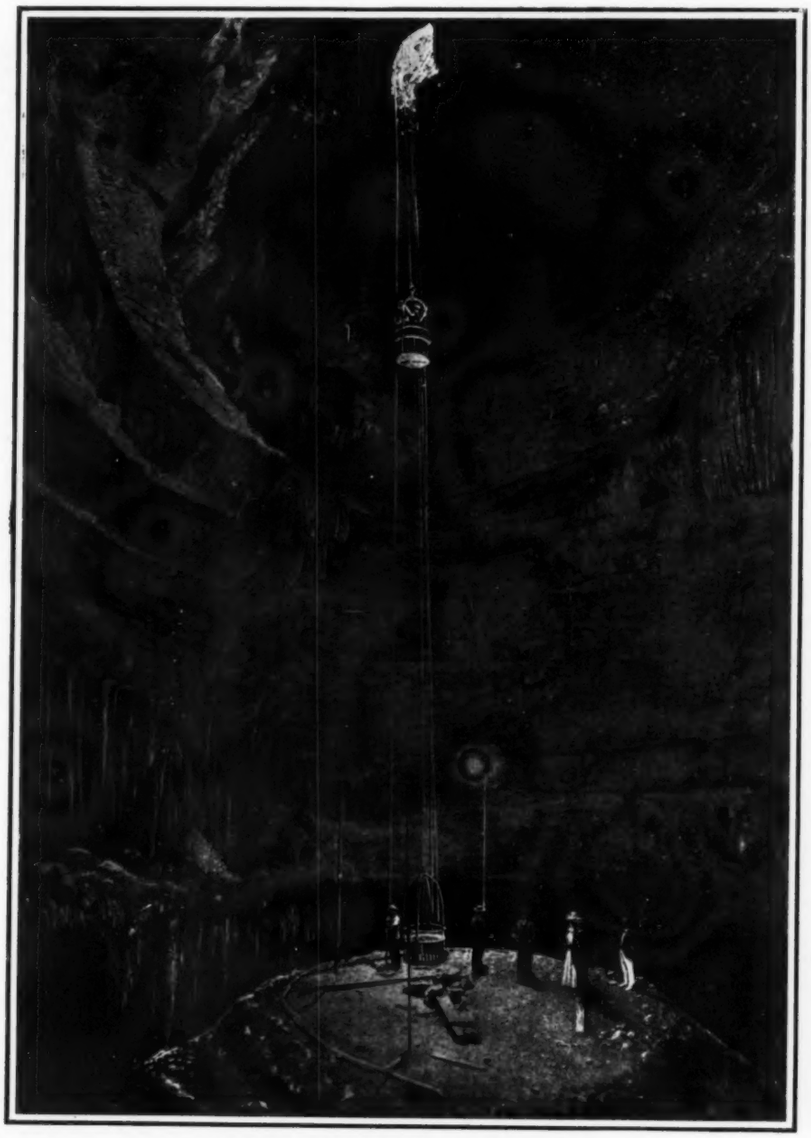
IN April, 1907, the newspapers of the south of France announced the discovery, or rather the re-discovery, of the cavern of Proumeyssac, in the department of the Dordogne. This venerable cavern formerly had an open mouth, into which many horses and cattle fell, and robbers, it is said, were accustomed to throw their victims. In consequence of these casualties the inhabitants of the neighboring communes, about 130 years ago, attempted to fill the cavern with stones and other material. Failing in this attempt, because of the unsuspected size of the cavity, they covered the mouth with logs and earth, and subsequently with a stone arch, the collapse of which led to the recent rediscovery of the cavern. M. Galou, who made the first descent into the cavern, with the aid of a rope, stated that its depth was 150 or 160 feet and that on the bottom he found a heap of stones 40 or 50 feet high as evidence of the old attempt to fill the cavern. He was able, however, to walk entirely around the heap and to explore a lateral gallery, filled with superb stalagmites, to a distance of 200 feet. Later, extravagantly expressed descriptions of the marvels of the cavern gave it a depth of 174 feet and added a cascade 80 feet in height, falling into a subterranean lake. It was even alleged that a duck placed in this lake has disappeared and emerged alive from a spring at Frémulot. In short, the cavern appeared to demand serious investigation and therefore I explored it thoroughly in July, 1907.

STALACTITES OF TRIANGULAR SECTION.



VERTICAL SECTION OF THE CAVERN.

THE LATERAL GALLERY.



INTERIOR OF THE CAVERN OF PROUMEYSSAC.

THE CAVERN OF PROUMEYSSAC.

Here are the facts: The mouth of the cavern is situated about two miles south of the Bugne bridge, in a plateau elevated 515 feet above the sea level and some 300 feet above the level of the river Vézère which is about two miles distant. M. Galou and others have set up a strong and well constructed windlass, with bucket and rope, by means of which the descent can be made with ease and safety. The descent, however, is only 108 feet, the bucket coming to rest at an elevation of 407 feet above the sea level on the top of a great conical mass, which is composed partly of the natural *débris* of the cavern and partly of the material which was thrown into it more than a century ago. At the bottom the cavern is oval in section, measuring about 200 feet from east to west by 130 feet from north to south. Beautiful stalactites hang from the walls but the finest and most extensive concretions of calcite are found around the base between the heap of *débris* and the wall of the cavern. A narrow natural gallery of snowy whiteness leads to a chamber where crystallization from a thin sheet of water has produced the curious triangular prisms shown herewith, and examples of the eccentric forms destitute of the normal vertical axis which are found in the cavern of Engihoul in Belgium and which I have endeavored to account for by colloidal and osmotic forces. In short, the cavern of Proumeyssac, with its very peculiar vertical shaft above, its great conical cavity beneath, and its beautiful concretions, should attract many tourists.

But it also possesses great scientific interest for the following reason: The situation of its mouth, in a level plain remote from cliffs and ravines, entirely excludes the hypothesis of its formation by the downward flow of a stream that has sunk into the ground. There is no trace, indeed, of the entrance channel and funnel which characterizes most of the caverns

that have been explored. By an exception which was once taken as the rule, but which is now known to be of very rare occurrence, the cavern of Proumeyssac has been excavated from below by the whirling action of a subterranean stream under great hydrostatic pressure.

The bell-shaped cavity, with its walls jutting inward by successive steps as they ascend, furnishes conclusive evidence of this mode of formation. The bell-shaped cavities found in deposits of gypsum have been excavated by a similar process.

The cavern of Proumeyssac is an unfinished cavern, for the action described above did not extend to the surface, but the pre-existent fissure in which the process must have originated was ultimately enlarged, probably by local rains, so that it now forms a vertical shaft about 6½ feet in diameter. The depth of this shaft, from the surface of the ground to the top of the bell-shaped cavity, is 26 feet, and its lower end, at the top of the bell-shaped cavity, is 82 feet above the top of the heap of *débris*. Hence, as the depth of this heap, so far as 4s known, is 16½ feet, the total height of the cavern proper may be estimated provisionally as 98½ feet. If the subterranean hydrostatic pressure had completed its work the roof of the cavern would have fallen in and a wide mouth, opening directly into the cavern, would have replaced the long and narrow shaft. This is precisely what has taken place in the great cavern of Padirac.

The cavern of Proumeyssac, therefore, affords an example of arrested development in cave formation, which is very interesting and almost unique. There are some other instances, but the caves are smaller or less sharply characterized. At present the stream which created the incomplete cavern has almost ceased to flow or is greatly diminished and lies buried beneath the mound of *débris*. The existence of the stream is proved by two facts:

1. There is a small spring a little to the west, at a level below that of the bottom of the cavern.

2. Several of the stalagmites that surround the heap of *débris* are broken off at the middle of their height. This phenomenon, which is frequently observed in grottoes, indicates a sinking of the floor, which is generally due to undermining by streams of water.

I regard the eventual discovery of this stream as a matter of pure chance. The depth of the *débris* is not definitely known and may be 50 or 100 feet. Furthermore, the walls of the cavern are entirely covered with calcite, which is very difficult to penetrate. The coating has been broken in several places without revealing any solution of continuity sufficiently important to tempt further exploration. There is no way of determining the point at which it is most likely to find an accessible passage. I may add that there is little probability of finding a channel of considerable size except in the up-stream direction, for in the opposite direction the stream has evidently encountered harder or less fissured strata which have checked its flow and thus developed pressure sufficient to excavate the cavern, probably at the intersection of a fissure extending upward. It has been proved by exploration that nearly all great caves have thus been formed at the entrance to narrow passages, which by their resistance to the flow of subterranean streams have developed pressures and currents by which softer strata were gradually worn away.

The temperature of the water which had exuded from the walls of the cavern and collected in little depressions in the stalagmite was found to be 54.5 deg. F.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

RECENT EARTHQUAKES.*

TREMBLINGS THAT PRECEDED THE ITALIAN SHOCK.

THE Italian earthquake still keeps a prominent place in the daily newspapers, and earthquakes still continue in the stricken country, but this is no more than must be expected. Every great earthquake is followed by numerous after-shocks, more frequent at first and gradually becoming fewer and fewer; 949 shocks were registered at Monteleone in 1783, and 159 in 1784. A similar experience is being repeated in Calabria at the present time. Reports of more earthquakes at Reggio and Messina are common in the papers, but the record is too incomplete to be worth repeating in detail. Among these after-shocks some have been of sufficient violence to bring down shattered or weakened walls and buildings, and some were of a severity which would have caused serious damage and destruction to buildings had they stood by themselves.

The first of these destructive after-shocks seems to have occurred at 7.24 P. M. on January 23rd, which brought down a good many houses left standing by the earthquake of December 28th at Reggio, and was described as of equal violence. This statement must be accepted with reserve, for experience has shown that after a very great earthquake and during the period when after-shocks are frequent, all sense of proportion is lost, earthquake-fear is developed, and every shock of more than average severity ranks out of proportion to its real importance. Though the shock was apparently a considerable one, and may well have compared in violence with its predecessor at Reggio, yet the much smaller area over which it had the power of inflicting damage, as also the much smaller size of the area over which it was felt, mark it as an altogether minor shock.

Besides the local after-shocks, earthquakes have been reported in the daily papers from other parts of the world, and not unnaturally a connection has been assumed which has probably no foundation in fact. The most important of these were the North American earthquake of January 11th, and that in Asia Minor on January 19th; the former of these was felt at Victoria, B. C., at 3.55 P. M., local time, and was described as severe; it was also felt at Vancouver and Nanaimo, in British Columbia, and in Washington State, where some slight damage was done at Port Townsend. The earthquake in Asia Minor seems to have been more severe if not more extensive. It took place at 6.40 A. M. on January 19th, and is said to have destroyed 679 houses at Phocœa, two persons are reported to have been killed at Menemen, and the same number at Cassaba. Neither of these was, however, of any importance, and would probably have passed without notice but for the attention directed to earthquakes at the present moment.

Much the same may be said of the shock which shook northern Italy on January 13th, though possibly this may have been of the nature of a sympathetic after-shock, that is to say, brought about by a change in the distribution of strains in the earth's crust, consequent on the movements which have taken place in Calabria. It belonged to that little understood class of shocks which affect a large area without anywhere reaching destructive violence, and nowhere did more than trivial damage, though felt at Triest, Trient, Milan, Genoa, Siena and in all the country between.

In spite of these earthquakes, there is no indication of any real increase in seismic activity; on the other hand, it is a somewhat remarkable fact that the Calabrian earthquake was a solitary one. World-shaking earthquakes almost invariably occur in groups, and are seldom unaccompanied by one or more companions, originating in distant parts of the globe, but within a few hours, or at most a few days, of each other. So frequent is this phenomenon that it has almost been elevated into a law, and an ingenious explanation, with experimental illustration, has been published. In the present instance the records of Prof. Milne's instruments at Shide show that no other world-shaking shock accompanied the Calabrian one, and none was reported until the morning of January 23rd, when an earthquake, which probably originated somewhere in western Central Asia, was registered by seismographs in Europe, India, and at the Cape of Good Hope. Probably we shall hear more of this earthquake, for its origin was in a region which is not devoid of villages and towns, but the interval which had elapsed prevents our regarding the two earthquakes as companions. This isolation of the Calabrian earthquake may find its explanation in the fact that although a great, it was not a very great, shock. The extreme diameter of the seismic area did not materially exceed 350 miles, and making every allowance, the area over which the shock might have been felt—including in this the sea—could not have been more than 95,000 square miles. In the California earthquake of 1906, the corresponding figure was 372,500, and in the Indian earthquake of 1897 it was 1,750,000. These figures give some idea of the relative magnitude of the three earthquakes, and in the present state of the science it does not seem possible to find a more satisfactory means of comparison.

A point which has attracted notice, and is worthy of attention, is the peculiar weather which accompanied and followed the earthquake. We need not consider the fact that it coincided with the sudden break-up of an equally sudden and severe frost over northern Europe, nor the unusual cold and snow storms which have followed it in southern Italy. These were due to meteorological conditions of great extent, in all probability unconnected with, and independent of, the earthquake, but the sudden fog which, according to every account, settled on the Straits of Messina stands in a different case. The earthquake in Mexico of January 24th, 1898, was similarly followed by a heavy mist, at a time of year when mists are usually unknown, and rainfall is so frequently reported as the immediate successor of an earthquake that we can no longer reject the hypothesis of a real connection between the two. Earthquake weather is a common expression in earthquake countries, but is usually applied to a heavy and oppressive feeling in the air which is supposed to precede an earthquake. Mr. Maxwell Hall has attempted to find an explanation in alterations of the barometric gradient by rapid upheaval of the ground, and has shown that uplifts, which are within the range of possibility, would produce the required effects, but whether there is, or is not, an earthquake weather, in the ordinary sense of the words, there seems reason for believing that in another sense they represent a reality, and that, as has been suggested by Prof. Milne, the disturbance of the ground, when transmitted to the overlying air, may determine precipitation, and explain the apparent association of severe earthquakes with mist and rain. What may be the nature of the influence we know not, but if mechanical, it must be either the result of the vibratory motion of the ground, or else of permanent changes of level, accompanied by the sudden upheaval or depression of the overlying column of air, and of this permanent change of level we are still without any satisfactory evidence. In the accounts which have reached us, quays and pierheads are mentioned as having subsided beneath the water, but there is nothing to show that more than a settlement of made ground has taken place, while the photographs which have been published suggest that this rather than any displacement of the solid ground is the explanation of the apparent subsidence, and the commission appointed to inquire into the changes which have taken place in the harbor of Messina has reported that though the quays have been destroyed in places, no permanent change has taken place which will interfere with the continuation of its use as a port.

* Nature.

AMOUNT OF FREE WATER IN THE EARTH'S CRUST.

THE problem of the amount of water in the earth's crust is of paramount interest to drillers and others seeking deep underground supplies, as well as to those interested in the problems of underground circulation as affecting mining. Probably no other question is so frequently asked in the field as that in regard to the water zone which most people suppose to exist somewhere below the surface, and which they invariably believe will always be found if a well only "goes deep enough."

In a report published by the United States Geological Survey as Water-Supply Paper 160, M. L. Fuller considers the subject of the total free water in rocks of various types, incidentally showing the absence of the immense "underground lakes" of popular imagination.

"Free water" is defined as the water that occupies the joints, solution passages, pores, or other openings in the rock, as distinguished from the chemically combined water in the minerals of the rocks. The free water has a more or less definite circulation even in the densest rocks, while the water in combination is not in liquid form, but is a part of the mineral compound itself. The free water should also be distinguished from the available water, for some materials, like clay, hold great quantities of water and yet give up only insignificant amounts. It is, in fact, possible for a rock to hold from 35 to 40 per cent of water and yet yield almost none at all to a pump—that is, almost none of its water is available.

Mr. Fuller's discussion necessarily deals with average conditions, for local conditions vary so greatly and so rapidly that generalizations of value can not be made from isolated regions. He concludes, after consideration of all the available factors, that the total free water held in the earth's crust would be equivalent to "a uniform sheet over the entire surface with a depth of a little less than 100 feet (96 feet). . . . If the average depth of the ocean is 14,000 feet, its volume is equivalent to a layer 10,500 feet deep over the whole earth's surface. The underground water would therefore be roughly only one one-hundredth of the volume of the ocean." This proportion has been computed by other investigators to be from one-half to one-eighteenth.

Mr. Fuller says: "There is a general tendency to overestimate the amount of water in the ground owing

to the impression of great volume which a large well conveys, the fact that a large area is drained being frequently overlooked. A study of the conditions in deep wells in the United States leads the writer to believe that the average amount of water present in the earth is probably under rather than over the amount estimated. While it is believed that the present estimate of the amount of underground water is fairly close for the earth as a whole, it is to be expected that the amount in certain materials and at certain localities will depart considerably from the figures given."

The report discusses in detail the factors used in the estimates, and gives a summary of estimates previously made by other investigators.

OLD AGE AND DEATH.

SCIENTIFIC DEVICES TO WARD OFF DECAY.

BY F. W. BECK.

A SCIENCE of senility has come into being but its doctors disagree. Metschnikoff and Loeb attribute the phenomena of old age to the accumulation of poisonous products of metabolism, which they regard as a pathological process. Ribbert, of Bonn, on the contrary, asserts that the deposition of waste products in the cells is a normal physiological process. The obstruction of the wasting cells with pigment and the accompanying increase of connective tissue are especially marked in the brain; hence brain failure is the commonest cause of death from old age.

Ribbert relies wholly on the microscopic examination of tissues, and appears to ignore the possibility of changes in the chemical composition of the blood, which might cause senility, as other changes produce various diseases. Even if the cell theory of old age is the correct one, it is conceivable that the cells might be induced by external influences to expel their accumulated waste products. A phenomenon may be universal without being normal or inevitable. Almost every human being has one attack of measles, but physicians do not regard measles as a necessary physiological evil which cannot be combated. The decomposition of dead bodies is as universal as old age, yet men learned how to stay the process six thousand years ago.

An American school of biologists, headed by Loeb, is already almost promising centuries of life to future generations. It is not a mere coincidence that the revolt against old age and death comes simultaneously with the attempted conquest of the air, for the possibilities of development of a species would certainly be brought out by change in the medium of locomotion. This is proved by biological history and also in the metamorphoses of insects and amphibia. Hence the infinite capacity for improvement, which man is supposed to possess, should be developed as his conquest of the air progresses. It is still undecided whether such highly developed unicellular organisms as rhizopods, flagellates, and citadel infusoria ever die a natural death.

Dr. Tranjen, of Plevna in Bulgaria, the land of longevity, proposes to make young persons immune to the poison of old age by inoculating them with infusions of the tissues of old persons, and to employ serum obtained from these immunized young persons in the treatment of senility in the aged. He has made experiments with animals and obtained encouraging results. Tranjen's theory contravenes the established biological canon which asserts that the qualities of two multicellular organisms can be combined only by coalescence of reproductive cells, but the assumption that nature is compelled to employ, for the transmission of organic qualities, vehicles as large as cells appears antiquated in this age of electrons and radiant matter, and it is refuted by well established facts. Hybrids between the hawthorn and medlar, the nightshade and tomato, the laburnum and clover have been produced by grafting, and these hybrids exhibit the mingled characters of their parents, as hybrid seedlings do. Furthermore, the elaborated honey, containing glandular secretions, with which bees feed their young is capable of transmitting physical peculiarities to young bees of other varieties.

Nor is rejuvenation of multicellular organisms impossible. A plant of the nightshade family, *Scopolia carniolica*, normally dies after producing seed in May or June. This is certainly a case of physiological, not pathological, senility. Yet the French botanist Daniel rejuvenated dying branches of *Scopolia*, and even caused some of them to bear seed again, by grafting them on certain young tomato plants.

Certain microscopic animal organisms possess the power of spontaneous rejuvenation, as was first discovered by the French zoologist Maupas. The rejuvenation is accomplished by means of a process called conjugation, in which two individuals adhere to each other, exchange part of the constituents of their nuclei, and thereby acquire fresh strength and vitality. This is the habit of the ciliated infusoria which, although unicellular, are of complex and highly organized structure and, according to some biologists, are endowed with intelligence.

By an unconscious analogy with the conjugation of infusoria man has attempted, from remote antiquity, to replenish the almost exhausted lamp of life with fuel drawn from healthy young bodies. The most harmless form of this practice consisted in sleeping with vigorous young persons of the same or opposite sex, and it may possibly have delayed, by suggestion, the death of the brain. This practice, which was followed even in the Middle Ages, was called "Shunammitism" from Abishag the Shunammite, who thus ministered to David. (I Kings I, 1-4.)

There were other and indescribable methods in which the influence derived from the youthful body was less ethereal and problematical than "nerve emanation," and there is historical evidence that such prominent men as the Duke of Alva and Prince Henry of Bourbon prolonged their lives several years by these methods. These cases appear to indicate that youth, like electricity and radioactivity, may be transmissible from one body to another, but the general practice of such methods would bring about the most grotesque sexual revolution that can be imagined.

Transfusion of blood was also in vogue, and was even recommended by physicians in the Middle Ages as a cure for senility. Even Hufeland discusses this method seriously in his *Makrobiotik*. An operation which often causes death, even when the fibrin is removed from the transfused blood, is too dangerous to be recommended, but an old man willing to sacrifice money and comfort might perhaps derive benefit from transfusion of blood accomplished by a different method. If superficial wounds are made in the flanks of two dogs or rabbits and the animals are bound together with the wounded parts in contact, they grow together and a slow exchange of blood takes place. In this condition of "parabiosis" with another, an animal can survive even the extirpation of so important an organ as the pancreas. Perhaps new life could be infused into an old person by such a Siamese connection maintained for some months with a healthy youth.

Soon after the discovery of radium some meal worms (larvæ of *Tenebrio molitor*) were exposed to the continued action of its rays. Most of the worms were killed, but some survived and continued to live in the larval state through two or three generations of weevils. In human life this is equivalent to prolonging childhood through two centuries. As the cells of insects and of human bodies are governed by the same vital laws, this experiment shows that the medieval search for the fountain of youth was not so absurd and contrary to nature as is commonly assumed.

All that human ingenuity can devise in the way of remedies against death may be compared for effectiveness to a single drop of water falling on a hot stone. A true science of death will not exist so long as we adhere to the naive assumption that all the causes of old age and death are to be sought within the body of the individual. If the law of conservation of energy is true and all things in the universe are connected together, the birth of a child must have an effect upon the longevity of every person on earth. Tables of vital statistics show, though vaguely, that the primal cause of any one man's aging and dying is to be sought in the children begotten by his fellow men. Goette, in 1883, announced, on biological grounds, that "propagation is the sole and exclusive cause of natural death," and Hartmann in his book on "Propagation and Death" (1906) calls these two vital phenomena the positive and negative sides of the same question. Regarded from this universal standpoint the universality of death is a synonym for the ubiquity of propagation, and the possibility of curing old age is tantamount to the possibility of suppressing the production of children. An experiment of great interest from every point of view could be made if all mankind could be induced to abstain from propagation for five or ten years, in order to determine the influence of such abstention upon the death rate.—Adapted from Prometheus.

CHINESE INCENSE STICKS.

THE following information regarding the manufacture of Chinese joss sticks in the city of Canton was prepared by Vice-Consul-General Willard B. Hull:

The manufacture of joss sticks (often known as punk in the United States) in Canton is quite an extensive industry, and the exports to foreign countries during the last few years indicate an increasing trade in that direction. During 1906 there were 1,598,800 pounds of this article shipped out of Canton, the value of which was $65,616, United States currency, while in 1907 the exports increased to 2,239,400 pounds, valued at $104,806. The declared value of exports to the United States during recent years was $26,175 in 1905, $3,015 in 1906, $20,339 in 1907, and $9,333 for the first nine months of 1908.

Having received several inquiries regarding joss sticks, especially the method of manufacture and the materials used, I recently visited one of the large firms where they are manufactured. I was told that in the manufacture of the best grades the following materials are used in making up a quantity of 30,000 joss sticks, namely:

Pounds.	Kind.	Cents per pound.	U. S. currency.
9	Sandalwood	5	$0.45
13	Kung heung wood	9	1.17
4	Cedar	4	.16
2	Sik liu powder	3	.06
3	Rhubarb	3	.09
½	Cloves	20	.10
13	Sheung shek	4	.52
11	Cheap sandalwood	4	.44
2	Yellow powder	3	.06
1	White sugar	3	.03
½	Chinese wine	2	.01
30,000	bamboo sticks	*50	1.50
Cost of labor for 30,000 joss sticks		*32	.96
Total			$5.55

* Per 10,000.

Some of the woods used in the manufacture of this incense are found only in China, and therefore no foreign names can be given them.

FACTORY PROCESSES—CURRENT PRICES.

The method of manufacture is very interesting. The various kinds of woods used are reduced by hand to a dust with rasps or files. The sugar and minerals used are ground to a fine powder in millstones. The materials, in the proportion mentioned, are then mixed in an urn, Chinese wine being used to moisten them, and are there thoroughly kneaded. When sufficiently mixed the mass is given to the man who rolls the sticks. This person sits before a table sprinkled with sandalwood dust, with a basket in his lap, in his right hand a wooden trowel, and in his left a bunch of bamboo sticks. The mixture is worked down to a body about the size of a large wire, when a stick is put onto the table and with the trowel the substance is skillfully rolled onto the bamboo stick. The alcohol in the wine causes it to dry rapidly and the sticks are ready for packing almost immediately. The workers are paid at the rate of 32 cents United States currency per 10,000 sticks, and an experienced man is able to roll as many as 8,000 per day, while the average is about 6,000 per day.

There are many kinds of joss sticks manufactured in Canton. The best grades are all made on bamboo sticks and vary in size, some being as long as 3 feet, while the shortest are about 1 foot. Others are made in the shape of spirals. The bulk of those shipped to the United States are of the cheaper quality, and are made chiefly of paper or bamboo pulp with nothing added to give it a scent. The market prices f. o. b. Canton of these poorer grades are as follows:

With bamboo sticks, 1 box containing 200 bundles, each bundle 10 packets, and each packet 18 joss sticks, per box, United States currency. $3.70

Without bamboo, 1 box containing 100 packets, each having 24 sticks 19 inches long, per box.. 1.00

With bamboo, 1 box containing 400 packets, each having 12 sticks 9½ inches long, per box..... 1.10

The four-masted schooner "Pendleton Sisters" is said to be the only sailing vessel in the world equipped with a wireless telegraphic outfit.

ARTIFICIAL UNWOVEN CLOTH.

SOME NEW PROCESSES OF MANUFACTURE.

BY A. CHAPLET.

THE manufacture of artificial silk has given birth to a new industry of similar character, the manufacture of artificial cloth directly from semi-liquid mixtures of cellulose. The process is still too new and too imperfect to be commercially profitable or practicable, but this was the case with Chardonnet's first method of producing artificial silk, yet the annual production of Chardonnet silk already amounts to 2,200 long tons and that of artificial silk of all kinds to 5,000 long tons, or one-tenth as much as the annual production of natural silk. Although the manufacture of artificial cloth is yet in the experimental stage, it has made considerable progress.

The idea was suggested about the middle of the eighteenth century by Réaumur, who terminated a description of the spinning apparatus of the silkworm with the suggestion: "As silk is only a dried gum, why cannot we make silk of gums or resins? Another idea which will perhaps appear strange but which may be practicable would be to make cloth, directly and without weaving, from such substances. Such cloth would not be composed of interlaced threads, but would be perfectly uniform. It might be made by pouring liquid silk on a great plate of glass, and it would have properties which no woven silk can possess, for it would be exceedingly lustrous, impervious to water, unaffected by dampness, and remarkably strong and light."

Réaumur's first suggestion has been realized in the production of artificial silk and his second suggestion in the manufacture of celluloid films, which, however, do not have precisely the qualities which he predicted. The threads of which woven fabrics are composed are capable of relative motion and the numerous air spaces further increase the pliability and confer the

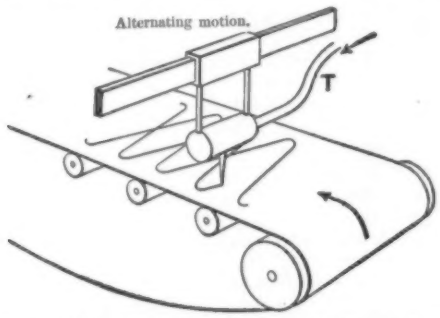


FIG. 1.—MILLAR'S APPARATUS FOR MAKING ARTIFICIAL CLOTH.

property of retaining heat. Hence in the older adaptations of Réaumur's idea to the manufacture of cloth, woven fabrics are combined with unwoven films. Thus a waterproof cloth is made by inclosing a thin sheet of India rubber or gutta percha between two woven fabrics.

Processes based on the mutual adhesion of threads.—The cellulose paste of which artificial silk is made is very viscous and its adhesive property has been utilized to fasten the threads together to form an imitation of cloth. With the aid of appropriate mechanical devices this process forms a cheap and satisfactory substitute for weaving.

In the method employed by the Vereinigte Kunstseide Fabriken threads of artificial silk are laid parallel, like the warp of a woven fabric, and are covered with a layer of the paste from which they were spun, which is then solidified and made waterproof in the usual manner. The luster of the fabric can be diminished and any desired color given to it by the addition of powders and dyes to the cellulose paste. The preliminary spinning of the warp and the subsequent operations make this process rather complex, and the product is merely a modified celluloid film.

In America, Millar has produced by a different method real cloths of various sorts which exactly resemble woven fabrics. Millar employs the initial process of making artificial silk, by forcing collodion or a solution of cellulose through capillary tubes by pressures ranging from 26 to 40 atmospheres. But instead of subjecting the filament thus formed immediately to the action of the coagulating, denitrifying, and purifying baths and then reeling it, he causes it to be deposited on a plane surface which moves in such a manner that the filament forms zig-zag lines (Fig.

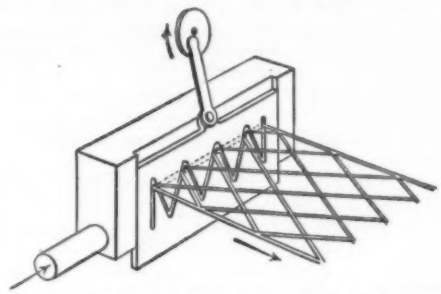


FIG. 6.—THE DROUINAT SPINNERET AND DIAPHRAGM.

2) which by their superposition and adhesion, form a network. (Fig. 3.) If the operation is conducted rapidly in a moist atmosphere the result is practically equivalent to a woven fabric.

The filaments are deposited on an endless band of smooth and non-adhesive material, such as waxed cloth, which is more than 30 feet long and is stretched over slowly revolving drums. (Fig. 1.) The spinning tubes, arranged singly or in groups over this band, have a reciprocating motion perpendicular to its length. By varying the speeds, periods, and amplitudes of vibration of the individual spinnerets a great variety of effects can be produced. (Figs. 3, 4, and 5.) The cloth is passed between rollers to assure the adherence of the threads, and is then subjected to the usual baths and drying processes of artificial silk manufacture. The filaments may also be deposited upon a thin woven fabric laid on the moving band, producing an imitation of embroidery.

The Drouinat process.—The artificial cloths made by the Drouinat process closely resemble the Millar products, but the method employed in their manufacture is quite different and more elegant. No filaments are spun but the cloth is made directly from the viscous paste. The original feature of the process is the employment of a spinneret which delivers the material in the form of a thin continuous sheet, of either uniform or varied thickness, which is immediately transformed into a perforated sheet, or net, by the action of a diaphragm moving in front on the spinneret. The orifice of the spinneret is a long and very narrow slit which, in the absence of a diaphragm, would produce a uniform thin sheet similar to a strip of celluloid film. If a diaphragm having a zigzag slit (Fig. 7, *O*) is moved up and down before the fixed slit the result is a diagonal net (Fig. 7, *E*), while a diaphragm of the form shown in Fig. 8 (*O*), moved in the same manner, will produce a straight net. (Fig. 8, *E*.) Other weaves can be imitated by employing suitable diaphragms.

In view of the difficulties which are encountered in spinning cellulose pastes (the great pressure required,

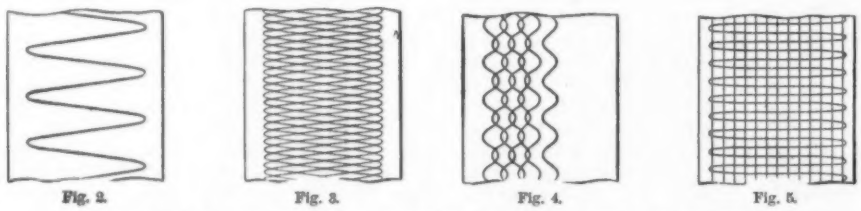


Fig. 2. Fig. 3. Fig. 4. Fig. 5.

IMITATIONS OF VARIOUS FABRICS BY THE MILLAR PROCESS.

the microscopic dimensions of the spinneret orifices and the frequent stoppages and breakage of threads by the presence of air bubbles and grains of dust) the Drouinat process, in its present form, does not appear practicable. The film issuing from the slit would certainly be full of holes and irregularities. In theory, however, the process is very interesting and it is doubtless susceptible of improvement. For example, could not the imitation cloth, or net, be cut or stamped from a thin continuous sheet obtained by passing viscose or collodion between rollers—as perforated sheet metal objects are made?—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

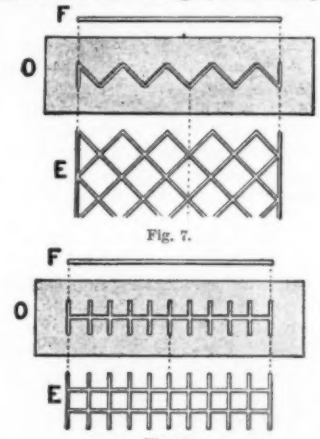


Fig. 7.

Fig. 8.

IMITATION OF DIAGONAL AND STRAIGHT WEAVES BY THE DROUINAT PROCESS.

F. Fixed slit. O. Moving diaphragm. E. Imitation fabric.

PROPORTIONS OF TRANSMISSION SYSTEMS.

LINES, substations, and transformers are uncertain elements of capacity and cost in transmission systems.

The location, size, capacity and type of the generating plant can be fixed exactly, and its cost can be closely predetermined, but the necessary length of line, the number of substations, and the number and capacity of step-down transformers are usually uncertain factors, when the construction of a transmission system is started.

Such uncertainty results from the fact that electric loads are not generally to be had ready made, but must be gradually built up as local conditions permit. In spite of the variations in these local conditions, many situations may be found that are more or less similar, and the following facts as to one transmission system have some bearing elsewhere.

The transmission system in mind is located in a territory destitute of large cities, but containing a good proportion of smaller places and an exceptionally large number of manufacturing plants, the majority of these latter being textile mills. After several years of successful operation and energetic efforts for business, this electric transmission system had a connected load of nineteen public lighting systems in as many small cities and villages, and nearly one hundred mills devoted to the cotton, woolen, iron, and woodworking industries.

For the operation of this load, current was distributed from forty-four substations with the aid of 41,750 kilowatts capacity in step-down transformers to the number of 131.

These substations and transformers were connected with the generating stations by circuits on 265 miles of pole and steel tower lines, and the generators themselves had a capacity of 30,600 kilowatts.

Per step-down transformer the average capacity was thus 317 kilowatts, but the smallest size was 100 and the largest was 1,000 kilowatts, while the 200 and 300 kilowatt sizes were the most numerous.

Among the substations the greatest capacity was 3,000 kilowatts, the least 200, and the average almost 950 kilowatts. No substation contained more than three transformers, and only two transformers were used in one.

Comparing the 30,600 kilowatts of generator capacity with the 265 miles of line, it appears that for each 1,000 kilowatts of this capacity the line of poles and towers, whether carrying one or two circuits, measured 8.3 miles. For each kilowatt of generators there was in use 1.36 kilowatts of capacity in step-down transformers, and each mile pole and tower line carried current to 157 kilowatts of these transformers, on an average. Per substation there were six miles of line.

In spite of the absence of large cities in the area served by the above transmission system, and the small average size of substations, the connected load of transformers per mile compares favorably with the corresponding loads of some other systems.

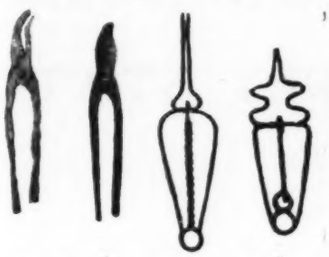
As the opportunities for using electric motors in scattered situations are realized, small substations on long transmission lines will become more profitable.

SURGICAL INSTRUMENTS OF ANTIQUITY.

WHAT THE ANCIENTS KNEW ABOUT SURGERY.

BY DR. PERCIVAL WINDMULLER.

On visiting the Saalburg museum a few years ago, I was impressed by the great number of surgical instruments there exhibited, and astonished by the practical construction of these implements, which were



a b c d

FIG. 1.—INSTRUMENTS FOUND IN THE SAALBURG. (100-200 A. D.)

a, Curved pincers as found; b, the same restored; c, modern American self-acting pincers; d, Roman pincers.

found in a well within the walls of the old Roman fortress and are about 2,000 years old. They are made of bronze, and are covered with a blue-green patina

FIG. 3.—POMPEIAN PISTON OF SYRINGE AND FORCEPS.

resembling that of old copper roofs. The collection gives evidence of an advanced state of surgical knowledge. It includes probes, delicate knives, and a laryngoscope (the only one that has come down to us from antiquity) which indicates that the Roman surgeons practised illumination of the mouth, and probably of

FIG. 5.—POMPEIAN PINCERS, FORCEPS, AND CATHETERS.

FIG. 6.—TROJAN KNIVES, SCOOPS, AND PROBES. (1500-1100 B. C.)

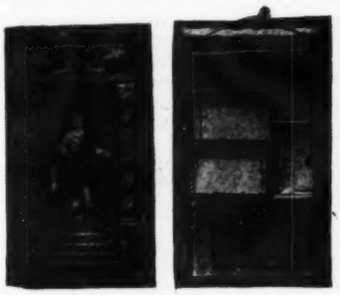
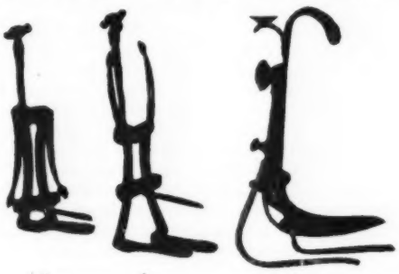


FIG. 2.—ROMAN MEDICINE CHEST CLOSED AND OPEN.

the throat and larynx. There is a small self-acting pair of pincers, which is as practical and efficient as the best modern examples. (Fig. 1.) It is probable



c b a

FIG. 4.—VAGINAL SPECULA.

a, Modern; b, Pompeian, opened; c, Pompeian, closed.

that the owner of these instruments was a specialist in diseases of the eye, for with them was found a syringe of the type employed by oculists of the period.

FIG. 7.—THE SOSIAS VASE (500 B. C.) WITH A REPRESENTATION OF ACHILLES DRESSING THE WOUNDS OF PATROCLUS.

The piston of the syringe is marked with the name Lepidus.

The sight of these interesting instruments led me to pursue the subject, and endeavor to collect other and

FIG. 8.—IAPYX EXTRACTING AN ARROW FROM THE THIGH OF AENEAS. (POMPEIAN PAINTING.)

still more ancient examples. The material contained in all other German museums is small in comparison with this rich collection in the Saalburg, but the Berlin Antiquarium and the museums of Switzerland and the Roman Rhine provinces give some insight into

FIG. 9.—EGYPTIAN INSTRUMENTS. (2000 B. C.)

the state of the art of surgery in the Roman empire. The Antiquarium possesses many antique probes, needles, and forceps, of practical and artistic design, and a medicine chest with a beautifully carved lid. (Fig. 2.) The wide extension of Roman civilization is illustrated by a bronze casket containing probes and surgical spoons, which was found in Servia, in the tomb of a surgeon of the Seventh Claudian legion.

FIG. 10.—EGYPTIAN DISSECTING KNIFE.

FIG. 11.—EGYPTIAN FORCEPS, KNIFE, AND SCALPEL.

Roman culture, however, was no more original than our own. It was derived wholly from Greece. Greek physicians came to Italy even in the early days of the republic, and at a later period they practised their art in every province of the Roman empire. The high culture of Herculaneum and Pompeii was the result of Greek colonization. The state of Greek surgery at the time of the destruction of Pompeii is illustrated by

FIG. 12.—EGYPTIAN MEDICINE CHEST. (2000 B. C.)

a unique collection of fifty instruments in the National Museum in Naples. In addition to various blunt and pointed probes, spoons, and hooks, the collection includes a dilating forceps, a forceps for cutting and extracting bone (Fig. 3), blistering cups, male and female catheters (Fig. 5), and, most interesting of all, two vaginal specula, one with three and the other with four blades (Fig. 4), which indicate that the art of

gynecology had already made considerable progress. These Pompeian instruments are far superior to any which have been found in Greece or Asia Minor.

But the beginnings of surgery must be sought at a far earlier epoch. The Berlin museum of anthropology possesses surgical instruments which were found in the ruins of Troy, or Ilion, and which consequently date from the period 1500 to 1100 B. C. These instruments (Fig. 6) are strikingly like those of Roman times. An antique vase (500 B. C.) bears a representation of Achilles dressing the wounds of Patroclus (Fig. 7), and the Naples museum possesses a Pompeian wall painting in which the physician Iapyx is shown in the act of dilating with the forceps a wound in the thigh of Aeneas, in order to extract an arrowhead. (Fig. 8.)

In antiquity Egypt was celebrated as the land of physicians. A few surgical instruments, very similar to the less ancient specimens described above, have come down to us from the middle period of Egyptian history. (Fig. 11.) Among them are probes of various forms, needles, forceps, universal implements in which pincers, knives, and probes are combined, and a dissecting knife of peculiar shape. (Fig. 10.) Another singular instrument is a long probe terminating in a pointed spoon, which was probably used by embalmers for the purpose of extracting the brain through the nasal orifice. A small medicine chest similar to the Roman one mentioned above has also been found in Egypt. (Fig. 12.)

W. Max Müller reproduces in his "Egyptological Researches" a very interesting relief found in a tomb at Sakkarah and dating from 2500 B. C., in which various surgical operations, including circumcision, are illustrated. Still older, and contemporary with Abraham and Hammurabi, is a Babylonian clay cylinder on which the cupping apparatus of the surgeon Urlugaledinn is represented.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Die Umschau.

THE SEWAGE PROBLEM POPULARLY STATED.*

THE BATTLE OF THE MICROBES.

BY CLARK P. COLLINS.

SANITARY engineering is that branch of civil engineering which is concerned with the constructions for promoting the health of the community.

It is wide in scope, but it can be generalized under two important heads, viz., water supply and sewerage.

In this connection it should be said that pure water supply and good sewerage are both essential, and that it is impossible to separate the value of one from that of the other.

A polluted water supply may spread disease, no matter how perfect the sewerage, and an abundant water supply is essential to the proper working of sewers.

On the other hand, without sewers and drains an abundant water supply simply acts as a carrier of filth to impregnate the soil.

No town or city can submit to a continued want of an adequate supply of pure water and a systematic plan for the removal of its wastes without a serious check in its prosperity.

Sanitary improvements are therefore among the first and chief duties of public officers and guardians, and should ever be the object of most earnest thought to those in whose charge and under whose direction these improvements are furthered.

Our rivers should prove a great blessing to our cities, and it is nothing short of a crime that their waters should be contaminated by filth.

Most foul and fearful of all the artificial pollutions which ignorant and careless humanity permits to reach the streams is the drainage of cess-pools, sewers and stable yards.

The authorities who subject their citizens to the dangers of water-courses impregnated with fecal substances, that the bodies of other persons and animals have already excreted, open for them the gates to aches and pains and weakness of mind and body.

There is no community, there are few families and comparatively few animals without disease.

In very large communities there is rarely a time when virulent disease does not exist, and unless the excretions from such sources are properly disposed of much trouble must be expected and many lives must pay the penalty of this sad neglect.

First—after water supply—for the health of any community is a carefully arranged system of sewers whereby these deadly enemies to mankind may be speeded away and properly disposed of.

This subject naturally invites our attention to the methods whereby the most favorable results may be reached, that the people who are called upon to bear the expense of these improvements may feel assured that the best plan has been adopted.

The methods of sewage disposal which are now practised in this country may be spoken of as crude disposal, disposal by chemical precipitation, by irrigation, and by filtration.

CRUDE DISPOSAL.

Crude disposal contemplates discharging the sewage in its crude or unclarified state into some near watercourse or body of water. This is usually by far the cheapest method of disposing of the sewage where the flow of the stream is large enough sufficiently to dilute the sewage at all seasons of the year; or should the town or city be located on the coast the sewage may be conducted in pipes into deep water and thereby sufficiently diluted to render it harmless.

CHEMICAL PRECIPITATION.

Chemical precipitation consists in collecting the sewage in tanks, having just previously mixed with it certain chemicals, usually calcium oxide or "lime," the result of which is to precipitate all matter in suspension and a portion of the material in solution.

A semi-fluid mass collects at the bottom of the tanks, called sludge, which may be drawn off or pumped into beds to drain and dry out, after which it is disposed of as the authorities see fit.

IRRIGATION, OR SEWAGE FARMING.

In irrigation the sewage is used to irrigate the crops, and the process is frequently called sewage farming.

It is very efficient when the land is of sufficiently porous, sandy or gravelly material, such being much better than that which is fine and more compact.

The sewage is discharged upon the ground, the coarser material being left on the surface, while the finer portions pass into the earth to a greater or less depth, depending upon the coarseness of the soil.

The water freed from the matter in suspension descends still further into the ground, coming in contact with the air in the earth. The impurities which it contains are thereby oxidized, that is, purified by the action of bacteria dependent for life upon the oxygen contained in the air.

The purified liquid may descend still lower, or it may be carried off in underground drains laid for that purpose.

The insoluble matter is also oxidized by slow combustion, and is thereby reduced to a fine powder and mingles with the elements of the earth.

In irrigation only such sewage is applied as will be beneficial to vegetation, and the prime object more often is the profit that may be derived from the crops raised.

Irrigation therefore requires a large area, and the difficulty experienced by cities in successfully operating sewage farms restricts the use of this method in the United States almost entirely to the arid regions, where the soils require irrigation anyhow and where water for irrigation is scarce and valuable. This method is used to a considerable extent in Europe, notably in Paris, in Berlin and in Birmingham and several other English cities.

From 5,000 to 25,000 gallons per acre per day may be purified by irrigation, the amount depending upon the porosity of the soil.

A very high degree of purification can be attained by irrigation.

FILTRATION.

With the exception of irrigation under very favorable conditions, intermittent sand filtration furnishes the most efficient means of purifying sewage which is in common use.

In this method the sewage is discharged intermittently upon the surface of sand filters from three to five feet deep. The area of filter needed will usually be one acre to every 100,000 to 150,000 gallons of sewage per day.

Any clean, good, coarse sand will answer for the filter.

The bottom of the bed is generally covered with a layer of graded pebbles or broken stone to make the drainage more nearly perfect.

The filter is usually underdrained by lines of drain tile, placed about twenty feet apart.

The theory of action of sand filters is, that upon the surface of the sand grains, bacteria of purification become established in innumerable quantities and work upon the organic matter in the sewage slowly trickling past them. In sand filters the bacteria are of the general class known as aerobic bacteria, or those which require oxygen to live.

Hence the application of the sewage must be intermittent to allow each dose to penetrate down into the sand out of sight and draw air into the pores after it, before the next dose is applied.

Sewage disposal plants having sand filters remove from 90 to 98 per cent of the organic matter from the sewage and from 98 to 99.9 per cent of the bacteria.

In case the highest efficiency of purification is not essential, sprinkling filters are used to very good advantage, especially when a very high rate of filtration is required.

The sprinkling filters are made of coarse material, say one-eighth inch to one inch in size.

Sewage flowing upon such coarse material would pass through the large pores too quickly to receive much purification. Hence the sewage must be sprinkled upon the top surface in drops to insure its simply trickling over the surface of the pieces of filter material.

There are many devices for distributing the sewage in this way, including principally perforated arms and spray-nozzles.

In the case of sprinkling filters, owing to the coarseness of the filtering material and the fact that the sewage is applied in drops and runs over the filtering material in films without filling the pores, sufficient air remains constantly in the pores of the filters to keep alive the aerobic bacteria of purification.

Hence the application of sewage need not be intermittent, as in the case of sand filters.

Sprinkling filters will purify from 1,000,000 to 2,000,000 gallons per acre per day, but they are not so efficient as sand filters. Fine black particles of partly purified organic matter often cloud the effluent to such an extent that settling tanks must be provided for clarification.

COMPARISON OF METHODS.

These form the principal methods of finally disposing of the sewage.

The first, viz., that of crude disposal, cannot now be classed as a scientific disposition of the sewage for inland towns and cities.

The country as a rule has been so denuded of timber that the rivers become very low during the periods of little rain, thus rendering this method of disposal at such times very dangerous; the flow of the stream not being adequate to dilute the sewage sufficiently.

In many States legislation prevents the adoption of this method.

Chemical precipitation, on account of the great cost of chemicals and labor required and the difficulty of satisfactorily disposing of the large amount of sludge precipitated, is now being considered a back number, although it was quite popular twenty years ago.

Only 45 to 50 per cent of the organic matter can be removed by this method, which in itself condemns its use in most cases.

The method of filtration is by far the best and is now being adopted all over this country.

As a preliminary treatment of the sewage in connection with the methods described, settling tanks and septic tanks are often used.

SETTLING TANKS.

Settling tanks are used in order to dismiss part of the solid matter from the sewage, which might tend to compact the filters.

Very little bacterial purification is carried on in the settling tanks.

SEPTIC TANKS.

In the septic tanks the sewage is retained for a sufficient length of time for the solid matter to settle and for a certain species of bacteria called anaerobic (for the reason that they do not require the oxygen of the air to live) to germinate.

In the decay of organic matter anywhere these germs are the active agents, and the septic tanks present very favorable conditions for the large development of the anaerobic bacteria.

The sewage is introduced into these tanks and allowed to stand sufficiently long for the bacterial action.

Usually the septic tanks are cleaned out once each year.

So much then for the final disposal of the sewage. We will now state briefly the two methods for the

* Abstracted from a bulletin published by the Merchants' Association of New York.

conveyance of the sewage to the place of treatment.

Two sewerage systems, the combined and the separate, have been successfully operated in this country and Europe.

THE COMBINED SYSTEM.

The combined system is one with which all towns are more or less familiar.

It consists of a single set of sewers calculated to receive and carry away a certain portion of the storm water flowing on the surface and all the house drainage and industrial wastes produced along lines of streets where sewers are laid.

Mechanically considered, it performs all these offices in a satisfactory manner and seems to comply with the requirements of purely engineering considerations.

It prevents sidewalks and streets from being overflowed during ordinary storms and generally disposes of the surplus water, clean or foul, with a considerable degree of completeness.

But let us see if there are not some defects in the method of disposal, even though some of the larger cities in this country have adopted the combined plan and consider it the most economical and practical one.

There are many cases where the combined plan would be preferable, especially where the point of outlet is far removed from the center of the city and where the sewage does not have to be treated, as when it is discharged into the ocean.

In order to provide for the removal of storm water, the sewers are made larger than are required for house drainage only; so that, during an interval between storms, the stream which would be ample to keep the sewer properly flushed, were the diameter small, is spread out over a larger surface and loses its power to keep it clean.

The sewer being large, the air space is large, and ordinary methods of ventilation fail to change its contents with sufficient frequency to prevent the formation of foul gases.

The drainage from the streets carries into the sewer foul rubbish of every sort, which remains deposited there to a greater or less extent.

These deposits form a nucleus for further accumulation of putrefaction from the solid matter of house drainage, leading to greater foulness of an infrequently changed atmosphere, and thereby requiring the house connections to be carefully trapped, lest they deliver foul and infected air into the interior of dwellings.

As combined sewers are made so foul in this way, it is also of great importance that their atmosphere be trapped away from the streets; and also that the amount of foul deposit may be reduced it is necessary to keep street rubbish out of them, and thus their inlets from the gutters are shut off by trapped catch-basins.

These become the receptacles of sand, chips, mud and droppings from the streets, forming together a polluted, rotten mass, a source of local infection, the dangers of which are manifest to all.

The whole tendency of modern investigation is to show that the zymotic diseases are produced by bacteria, where germs are developed under favorable conditions.

It is well known that the most favorable conditions for the growth of these low organisms are heat, moisture, darkness and the presence of ammonia.

The damp walls of sewers present, therefore, all the requirements for the most abundant growth of these bacteria, whose germs may float off on the sewer air and be carried into dwellings by mechanical action, as dust is borne into our windows.

Large sewers necessarily become the hotbeds for the propagation of these deadly organisms, the moist, porous walls forming a good soil for the pestilent growth, the ammonia from the sewage supplying the nutriment essential for their development, and the moist, warm air completing the process.

The storm water falling per hour in violent rains over an area of closely built-up city land is nearly fifty times the amount of waste water and sewage produced per hour in the same area.

The sewage, therefore, is a mere trickling thread in the bottom of a sewer large enough to carry off storm water.

Let us suppose the sewer in question be one built of brick. In time of rain the sewer will be nearly or quite full of diluted sewage which is absorbed by the bricks and leaves a coating on them, as the flow decreases.

The velocity of the stream being great, enough power is gained to carry along with it particles of solid matter which, as the stream subsides, are deposited along the water line of the sewer. These deposits form miniature dams at first, but are greatly enlarged by the constant additions of solid matter from house drains, which during the dry weather have not sufficient depth of flow to carry the matter on. Foul gases are then emitted, which in themselves are a source of great discomfort and danger.

The occasional flushing of these large sewers, while it may clean out silt and accumulated filth and thus decrease the amount of heat and ammonia from decomposition, can never prevent the growth of bacteria on the sewer walls, nor will ventilation prove efficient.

Every device of engineering has been exhausted to keep large sewers clean and well ventilated, but the air from them is still deadly.

Experience, therefore, has taught and is teaching that there are some radical defects in the system of large or combined sewers.

Perfect plumbing may prevent sewer gas from entering dwellings, but perfect plumbing is a rare exception, especially in rented houses.

In view of this fact, are we not forced to conclude that the combined system is defective as far as sanitary requirements are concerned?

Each and every town has, as a rule, certain requirements to be met, when a system of sewerage is to be devised, which should regulate the choice of the method to pursue.

Naturally, great attention should be paid to economy, and, other things being equal, economy should control.

Where the special requirement is to dispose of a surplus of surface water during storms, this object should be in precedence to all else, yet the sanitary requirements must not be forgotten.

All sanitarians are agreed that the chief aim, as far as removal of foul waste is concerned, whatever may be the system adopted, should be immediate and complete; and this principle of immediate and complete removal should apply to all laterals as well as main sewers.

THE SEPARATE SYSTEM.

Let us now turn our attention to the separate system and see wherein it differs from the combined.

In this method the chief aim is to separate the house drainage from the surface drainage, and storm water, where it is necessary to be carried off in conduit, is disposed of through special storm water sewers.

By this separation, much smaller sewers will suffice for the house drainage, and on this account the flow through them will be more constant and there will be less chance for deposits, and less wall surface will be exposed on which bacteria can germinate, and there will be less space for storing up germ-laden air.

The gases and heat decomposition which so powerfully stimulate the growth of organic matter are prevented by thorough daily flushing, which is practicable only in small sewers. The smooth glazed surface of the pipe-sewer is unfavorable soil for this vegetable growth, compared with the porous bricks, moistened with sewage.

So much smaller sewers will suffice to carry off the sewage only that their cost need be but a fraction of what would be required to build sewers admitting rain; and by adopting this plan many towns can avail themselves of the benefits of sewerage which would otherwise be prevented by this extra expense.

THE MEMPHIS SYSTEM.

It was at Memphis, Tenn., that the separate system of sewerage was first given a practical test. In the year 1878 the city was visited by a dire contagion, the deaths resulting from yellow fever alone amounting to 5,150. This city naturally became an important subject for sanitary discussion. Many engineers were called upon to give their views as to the best way to cleanse the city and make it habitable.

The plan submitted by the late George E. Waring was finally adopted, and in January, 1880, the work was begun.

All those interested in sanitary improvement now turned their attention to Memphis, for Waring's plan was the separate system pure and simple, and this was a vital test of its efficiency.

The house drains were four-inch pipes, and the sewers ran from 6 to 12 inches in diameter, except in special cases where larger pipes were used, but these were rare.

Flush tanks were put in and rendered very good service.

The effect of the flush is not only to wash out the sewer, but also to force air through the house drains, which it has been frequently observed to do with considerable power.

The report of the City Engineer of Memphis for the year 1886 was very favorable and spoke very highly of the result of the finished work.

In places of moderate size the accumulations of storm water can be led by short and inexpensive drains directly to a suitable outflow without being taken in artificial channels over a longer course, and this applies to a greater extent than is generally supposed to large cities. Since the separate system of sewerage underwent its first test at Memphis in 1880—and from that time it has been known as the "Waring system"—it has been adopted in a great number of towns and cities, and the results are most favorable.

Flushing tanks, by the regularity and frequency of their discharge and by the large body of water precipitated into the dead end of the sewer, sweep out with one rush any chance accumulation of filth. The flush caused by the introduction of rain water through sewage is constant and wholly dependent upon its intensity.

The flush from an automatic flush tank is sudden and violent.

Considering 1 inch per hour as the maximum rainfall, from the roof of a house 25 x 50 feet in size, or 1,250 square feet in area, there will flow 780 gallons in one hour. The flush tank discharging 160 gallons in fifty-five seconds, which was the average capacity of those at Memphis, would have great advantage over the former, for while the roof discharges 780 gallons in an hour, in fifty-five seconds it would discharge only 12.37 gallons; so in violent storms the discharge from thirteen buildings of the above dimensions would be necessary to equal that of the ordinary flush tank.

In case the sewage has to be purified, the separate system is more economical, because only the sanitary sewage need be treated.

GENERAL CONCLUSIONS.

The general conclusions of sanitary engineers at present regarding the relative merits of the separate and combined systems are as follows:

(a) Either system can be made satisfactory from a sanitary point of view.

(b) On a basis of cost the separate system is usually best for small cities and for all cases, even in large cities, where the sanitary sewage requires treatment, while the storm water can be safely discharged into nearby water-courses. The separate system is to be used in Baltimore on this last account.

(c) Often a combination of the two systems can be used to advantage, storm water being admitted to the sewers only in certain business districts.

It appears, generally speaking, unwise to dilute sewage with storm water and to befoul storm water with sewage in the attempt to remove both by the same underground channel.

While a foul and ill-ventilated sewer is always a source of danger and much worse than none at all, a well planned, well built, well used, well ventilated and well flushed sewer approaches very near to sanitary perfection.

To those who are interested in the treatment of sewage a visit to the city of Worcester, Mass., affords a very excellent opportunity to study the most up-to-date methods now practised in this country.

At Worcester they are using chemical precipitation, intermittent filtration, sprinkling filters and also the septic process as a preliminary treatment.

At Worcester, it is stated, they can handle 150,000 gallons per acre per twenty-four hours by intermittent filtration, and by the sprinkling filter process a daily capacity of 1,000,000 gallons per acre can be realized.

Chemical precipitation appears to be a back number on account of the low degree of purification and the large quantity of sludge which must be disposed of.

LAYING CONCRETE IN COLD WEATHER.

IT IS always risky work for property owners or builders to lay concrete during cold weather, but in extreme cases this class of work can be done if proper precautions are taken. In the cold and damp winter months concrete sets more slowly than during the warm periods, and for this reason it is argued that the centering under it must be left in position for a proportionately long time. A writer in a recent issue of Municipal Engineering says that below a temperature of 50 deg. F. concrete sets slowly, and below 40 deg. is very inactive. At 32 deg. concrete freezes before setting. Remove any concrete known to have been frozen. A slight frost extending only one-fourth of an inch into concrete is not detrimental to strength. Some builders claim that concrete can be frozen, thawed out, and will then reset. This may be so in many cases, but it is always best to remove any concrete in which the freezing has extended throughout the mass.

Concrete work can be carried on when the temperature is as low as 20 deg. (never lower), if the precaution is taken to incase the building with canvas and place heating grates or salamanders under the floor being concreted. Keep the building at a uniform temperature of about 60 deg. Do not allow intense heat to come in contact with the concrete, as it will dry out the concrete before it has set. Cover the concrete after being laid with some good insulating material, such as sawdust, straw, cement bags, manure, etc. Be sure to cover the concrete work before stopping work at night, even though it is warm during the day time. Salt dissolved in the water used in mixing concrete helps to prevent freezing by lowering the freezing point. A 5 per cent solution (by weight) of common salt is ordinarily used and is not detrimental to strength when so used. Calcium chloride has an advantage over salt in that it reduces the freezing to a lower point. Dissolve in the water needed to properly mix the concrete 2 pounds of calcium chloride for each bag of cement used.

Heating the cement, sand, stone, and water used in the concrete is helpful, but the materials must never be heated to a temperature of over 100 deg., as the strength of the concrete will be weakened. Be sure that the concrete is thoroughly set (not frozen) before any centering is taken down. Leaving all the upright

supports in place, remove the sides of the columns and beam boxes and thoroughly examine the concrete. Then remove the slab centering, and lastly the main supports. Leave the centering in place a few days longer rather than take chances. Do not take down the centering too soon.

ENGINEERING NOTES.

In a recent issue of Engineering it is stated that an engine built in 1808, or over a hundred years ago, for a British firm, by Messrs. G. Rennie & Co., of Greenwich, England, has just failed by the breaking of the crankshaft. The company which built the engine has been called upon to make repairs, and after an examination of the rest of the engine, it was found to be in excellent condition, so that it has been concluded to set it to work again as soon as the repairs have been completed.

The process of cutting metals with a jet of oxygen has been successfully employed in the removal of a cage loaded with six cars of coal which had fallen to the bottom of a French mine shaft from a height of 500 feet. The eight posts of the cage were severed, near the top, in fifteen minutes. The roof and the cars in the upper story of the cage were hoisted successively to the surface. The posts were then cut below the intermediate floor, and this floor, the cars beneath, and the bottom of the cage were raised in the same manner. The whole operation, including the removal of the mud in which the cage was imbedded, was completed in less than twelve hours. With the old methods and without using dynamite, it would have occupied several days.

In an interesting paper read before the American Society of Civil Engineers, J. A. Waddell contributed some valuable material to the prominent subject of using nickel steel in bridge building. Summarizing from the results of his experiments, covering a period of five years, he pointed out that nickel steel is in every way fitted for bridge construction, in that it is strong, tough, workable, and reliable; moreover, its adoption would effect a decided economy. This economy would increase in the future as the cost of nickel decreases, and as the shops become more accustomed to the treatment and handling of the new alloy. That nickel will soon be less expensive is almost a foregone conclusion, in view of the enormous deposits of nickel that have been found in existence in Canada. It is stated on good authority that there has been found in one deposit in that country ore containing fully 200,000 tons of the metal, and the outlook for an enormous supply is bright.

Despite the wonderful strides that have been made in regard to the evolution of various mediums of illumination which are supplied in bulk from central supply stations, the lamp is still extensively used by the poorer classes of the community and in those rural districts where other systems are unavailable. That the employment of such an article is attended with grave dangers a perusal of the numerous fatalities directly attributable thereto strikingly shows. But the lamp will never become obsolete. Under these circumstances inventors are devoting their energies to the contrivance of a simple, inexpensive article which is absolutely safe under all and varying conditions, while attractive prizes are still available to stimulate the inventive faculty. But the safety-lamp has so far resisted discovery. In the meantime, however, the nearest approach thereto has been achieved by a Scottish scientist, whose invention promises to come into extensive vogue. Though petroleum, one of the most inflammable liquids known, constitutes the lighting medium employed, its use is carried out upon such lines that explosion or fire arising therefrom is quite impossible. The lamp is, moreover, of simple design. It comprises a special porous stone which is immersed in the oil and becomes thoroughly saturated therewith. This absorbent medium has a hole pierced through its center extending to the orifice where the wick is generally placed. The stone is placed in a metallic receptacle which is so devised that a current of air can circulate through the channel in the absorber. The burner is placed in the usual position, and carries an incandescent mantle. To light the lamp one simply places a burning match to the burner. This causes an upward draft of air, through the stone, which in its passage mixes with a small percentage of the gas of the petroleum, and the mantle becomes incandescent. So long as the latter is alight the upward draft of air continues, but directly the lamp is upset it is extinguished. It cannot explode by any possible means, since the proportion of light hydrocarbon with the air is so small, while directly the absorbent stone becomes exhausted the flame simply expires. There being no free liquid in the vessel, it cannot catch fire. So simple and safe is the lamp that a child can manage it with absolute safety. For country-house lighting it is an ideal and economical system. The lamp is supplied in a variety of styles usually associated with oil illumination, ranging from a few pence to several pounds in cost, so that every requirement is met.

ELECTRICAL NOTES.

A fact that seems to have been established with reference to the relative cost of operating steam and electric locomotives is that it takes 30,000 miles of running to wear down the tires of an electric locomotive 1/32 of an inch, whereas under exactly similar conditions the same amount of wear takes place in from 8,000 to 9,000 miles of running on a steam locomotive.

It is sometimes interesting to know the nature of the current supplied by an electric plant, to know if it is an alternating or continuous current. There are of course several methods, but the easiest and cheapest is the following: Approach a magnet to an incandescent lamp fed by the current the nature of which is to be investigated. If the current is continuous, the filament will be seen to bend toward the magnet each time it is brought to the lamp; if the current is alternating, the filament will be seen to vibrate synchronically with the current, and to give to the eye the illusion of being of variable thickness. These phenomena are very distinct, and manifest themselves by using even a small pocket magnet. For the installation of equipments requiring a certain current (as arc lamps, small motors, the charging of accumulators, etc.) this method of ascertaining the nature of the current could be easily used, if no information about the power plant were at hand.

At first magnetic separation of ore was only applied to the naturally magnetic ores, magnetite and magnetic pyrites; it was soon, however, extended to certain other minerals that can be rendered magnetic by heating, such as spathic iron ore, brown hematite, iron pyrites, etc. As early as 1875 a magnetic separator was used at Przibram for separating roasted spathic ore from zinc blende, this forming an excellent example of the value of magnetic separation. The presence of spathic iron ore causes great difficulties in smelting zinc ores, as it forms a readily fusible silicate of iron which destroys the zinc retorts; at the same time, the densities of the two minerals are so nearly the same that separation by ordinary dressing is impossible. The application of magnetic separation has solved the difficulty, and has rendered available for the smelter numerous ferriferous zinc ores that were previously useless. The process is receiving an extended application in America for treating argentiferous galena and zinc blende, finely divided, and intimately mixed with a large proportion of iron pyrites, in which the proportion of zinc is too high to admit of the ore being smelted direct, while the large amount of iron pyrites present interferes with ordinary wet dressing. This ore is crushed and then gently heated, which renders the pyrites magnetic, so that it can be removed by a magnetic separator; the dressing of the residual mixture of zinc and lead ores by the ordinary methods then offers no particular difficulties.

Between five and six o'clock in the afternoon of June 26th, 1908, a thunderstorm broke out in the department of Vaucluse, in the south of France, and extended over a length of about 10 miles and a width of 1¼ miles. Its course coincided with that of an electric power line which carried a triphase current at a tension of 45,000 volts. This line follows a sinuous course, running nearly parallel to the Luberon mountain range, which is about 3,500 feet high and is locally regarded as a cause of hailstorms. The distance of the electric wires from the mountains varies from two to three miles. The thunderstorm followed all the sinuosities of the electric wires, and produced its maximum effects in their immediate vicinity. The damage done by the storm decreased in proportion to the distance from the wires and became imperceptible at a distance of about 3,000 feet on each side of them. A landowner who resided near the place of origin of the storm and about 1,300 feet distant from the wires saw three balls of fire, each twice as large as a man's head, hover about the wires an instant and then burst with an explosion which was immediately followed by a shower of hail. It appears that the storm was guided in its course by the electric wires, but was it provoked by them? Only conjectures can be given in response to this question. Although the experience of telegraph companies long ago proved that the electricity of thunderstorms may be conveyed to the telegraphic instruments by the wires, the high tension power lines that have been in operation during recent years have not yet appeared to be especially liable to injury from lightning. Moreover, it has been demonstrated that these lines are not a source of danger except to objects in their immediate vicinity. Are we to conclude that they cannot, in any case, exert an influence upon storm clouds? M. Violle, who reported this case to the Academy of Sciences, thinks that this conclusion is not justified. Between the cloud and the line is formed a continually varying field of electric force, the existence of which is manifested by strong electric effluvia. It is readily conceivable that so intense a field might, even at great distances, cause changes of potential which would produce showers of hail.

TRADE NOTES AND FORMULÆ.

Isochrome Varnish (to give colored copper plate engravings the appearance of oil paintings).—250 parts of coarsely powdered mastic and 125 parts of fine glass powder are mixed with 1,125 parts of oil of turpentine and allowed to stand, being constantly shaken, for 2 days, then 50 parts more of turpentine are added. The mixture is exposed for a few days to the sun and filtered.

Glass Substitute.—4 to 8 parts of gun cotton are dissolved in an adequate quantity of ether; this solution is mixed with 2 to 4 per cent of castor oil, or any other non-resinifying oil, and from 4 to 10 per cent of turpentine added to the mixture. The mixture is poured on to a glass slab and dried by a current of hot air, which, in a comparatively short period, transforms the fluid into a perfectly transparent, hard, amorphous plate, the thickness of which can be regulated as desired.

Insulating Varnish.—An elastic, flexible varnish, that will not scale off, for coating wood and iron structures, also as an insulating medium for damp places, as a protection against dry rot, as well as for the waterproofing of articles of clothing, and as a coating for folding wagon covers, may be made as follows: Slake about 15 parts by weight of lime with 20 parts by weight of water, add about 50 parts of hot, melted raw caoutchouc (rubber), mix thoroughly and add to the whole, constantly stirring, 50 parts of boiling linseed oil varnish. When, by stirring, a homogeneous mass has been produced, filter it and allow it to cool. In painting with it, the mixture is thinned with the necessary proportion of varnish and is best applied warm. Drying requires about two days.

To Color Light Horn in Imitation of Tortoise Shell.—To effect this, prepare a mixture of equal parts of burned lime, potash, oxide of iron, and pulverized graphite, rub all the ingredients thoroughly together and add enough water to make them into a thin paste. The horn, polished to a finish, is dipped, for a short period, in warm, dilute nitric acid and then laid in cold water, then dried thoroughly, and after a time the paste above described is applied to the parts to be colored brown by means of a small pad of wadding, the paste being allowed to remain on the parts for two hours or longer, according as the color is to be lighter or darker. After this time, the paste applied is removed by means of a stick (for it colors the fingers black) the horn is washed off and left for 8 to 10 hours. Finally, it is polished with soft soap and Vienna lime. The natural appearance is obtained with a little practice.

Honey Wine (according to Dzierzon).—In a polished copper kettle, mix 12½ parts of honey with 55 parts of water, allow it to boil gently and skim off the scum. After half an hour, introduce gradually 1½ parts of finely crushed chalk, constantly stirring. The tough substance this forms on the surface is skimmed off, and when no more appears, pour the fluid into a wooden vessel, so that as it rests and cools, the chalk will settle. The fluid is then carefully poured off, so that all the chalk is left behind, returned to the kettle, which has again been cleaned, where it receives an admixture of 3 parts of pulverized charcoal, well purified by heating to redness. It is then poured for the second time into the cleansed wooden vessel, cooled, then filtered through a conical bag of felt or flannel. It is then returned to the kettle and heated to boiling. In the meantime, the whites of 25 eggs are beaten with water, to a foam and gradually added to the fluid. By this means it is completely fined, the egg-white, taking up any particles of charcoal or other impurities, to be removed as scum. The chalk takes away the acid, the charcoal the waxy flavor. The fluid having boiled for an hour after the addition of the egg-white, it is cooled, racked into a cask, which should not be quite full, a small space being left at the bung-hole which is covered with a piece of clean linen, and the fluid left to spontaneous fermentation. In other respects the process is the same as in making mead. Cleared in the cask and racked into bottles, the wine will keep for more than fifty years. A cool cellar, of a temperature of 38 deg. to 40 deg. F., is an important factor. The bottles are placed in damp sand which is moistened, from time to time, with salt water.

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